A Way to Measure Community Noise in a Complex Acoustical Environment

TRB ADC40-Dayton Meeting

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Introduction

Environmental Noise Monitoring System

Used for

- Road traffic noise
- Construction noise
- Rail yard and rail pass-by noise
- Factory noise

The system allows you to

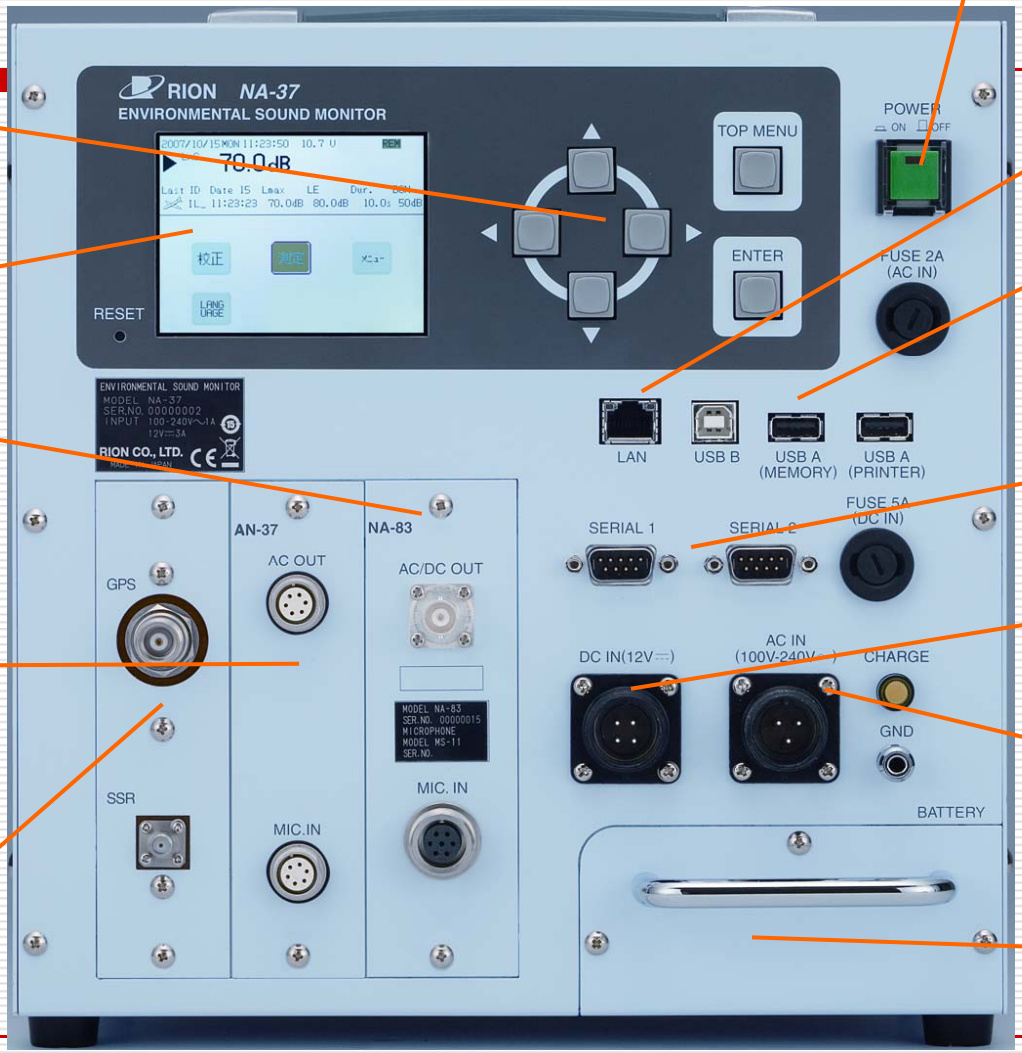
- Collect environmental noise data
- Store data
- Recall and analyze data

The Environmental Noise System

- Environmental Noise Monitor
  - Sound Level Meter
  - Outdoor Microphone Set
  - Environmental Noise Processing Program
  - Noise Identification Unit (to detect a direction from sound source)
- Data Processing
  - Environmental noise data processing software

Basic System

RION NA-37 Front Panel



Operation keys

Color LCD

Sound level meter NA-83

Identification unit AN-37

GPS module

Power switch

LAN

USB

RS-232-C

DC connector

AC connector

Internal battery

Sound Level Meter NA-83 for NA-37 (1)

- Compliant with IEC 61672-1 Class 1
  (with all-weather windscreen and
  microphone extension cable)
- Periodic calibration just means removing a small unit.

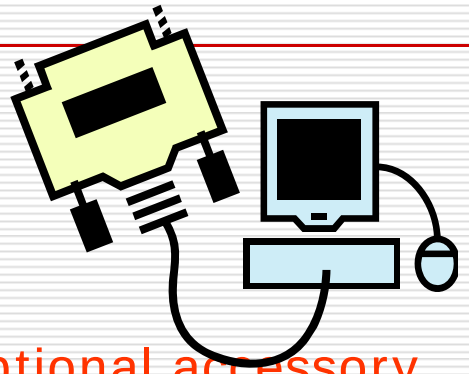
  - Rain and wind resistant
  - EMC shielded
  - Remote calibration check

Features

Options available to extend NA-37 functions

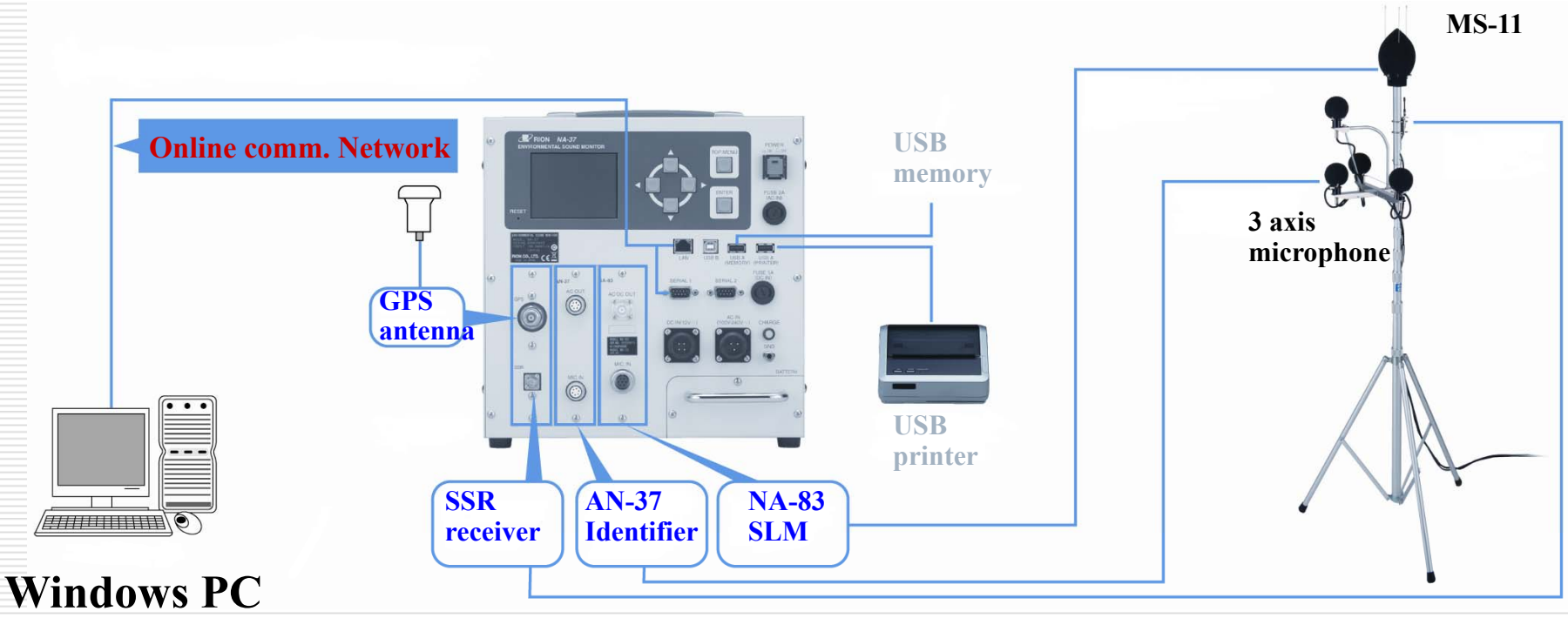
- Automatically adjust clock
- Automatically record measuring coordinates
- Check data at measuring site
- Receive and log weather information

Features



- Communication interface
  - LAN
  - RS-232-C
  - Modem (through analog public line)
- Sound recording functions (when using optional accessory NX-37WR)
  - MP3/WAV format
  - Level trigger/interval trigger
- Massive internal memory capacity
  - E.g. 40 days with 1,000 events/day and sound recording with NX-37WR and MP3 format (in 5 sec sampling)
- Data extraction
  - On-line communication
  - USB memory stick available

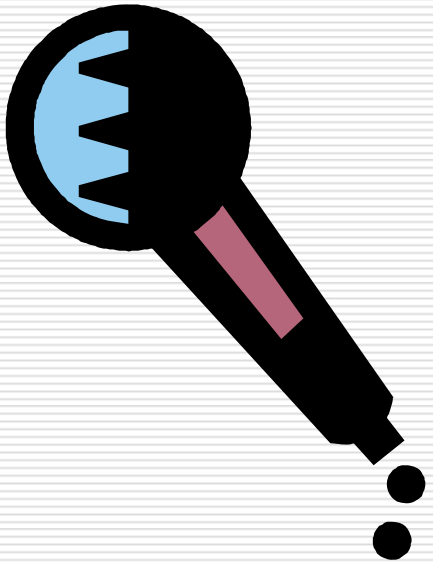
System Configuration-Example



Measuring Microphone and Windscreen

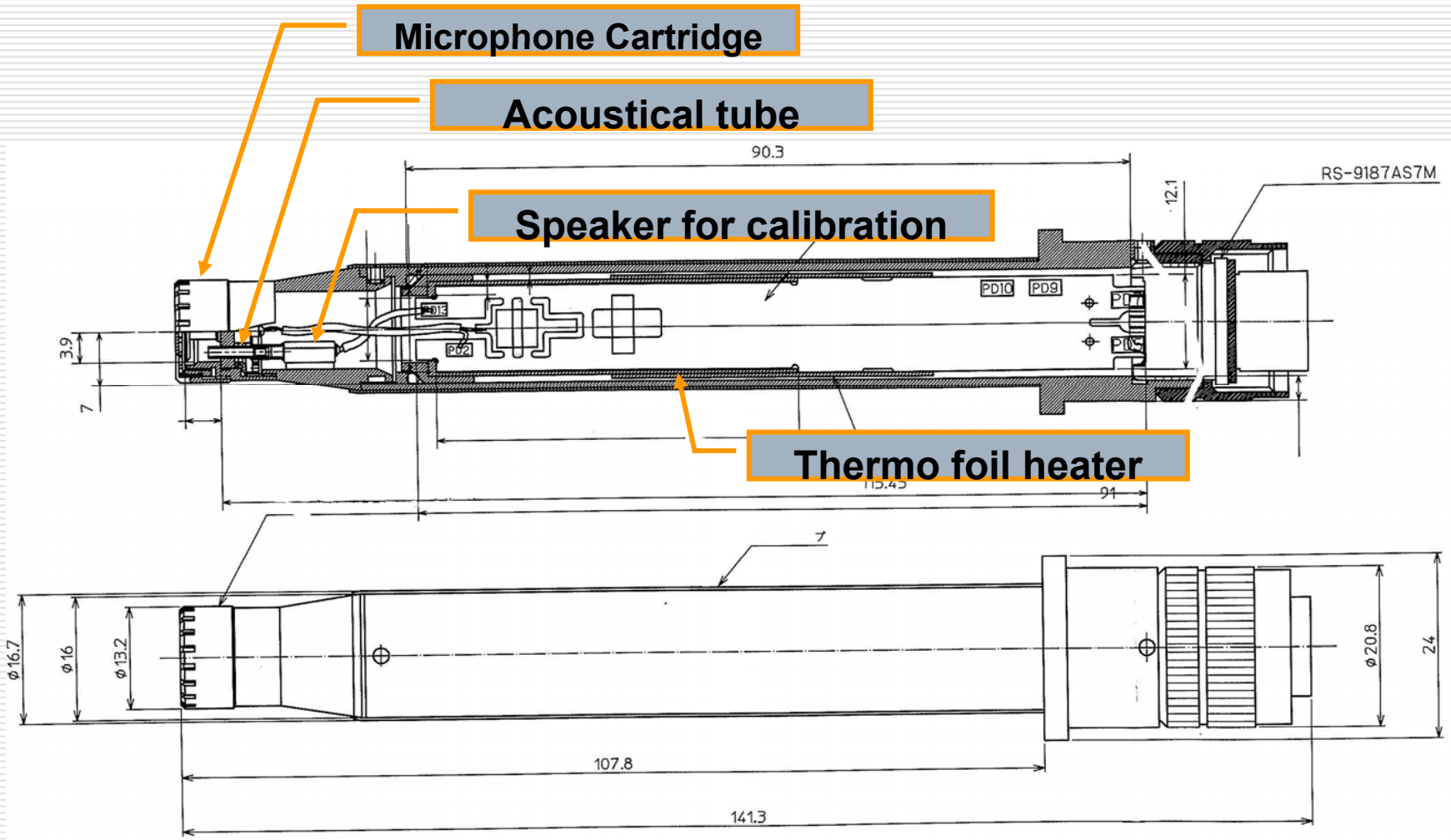
Measuring Microphone

- Microphone section
  - Compact windscreen
  - Built-in calibration sound source
  - Built-in heater to prevent condensation
  - Bird spike

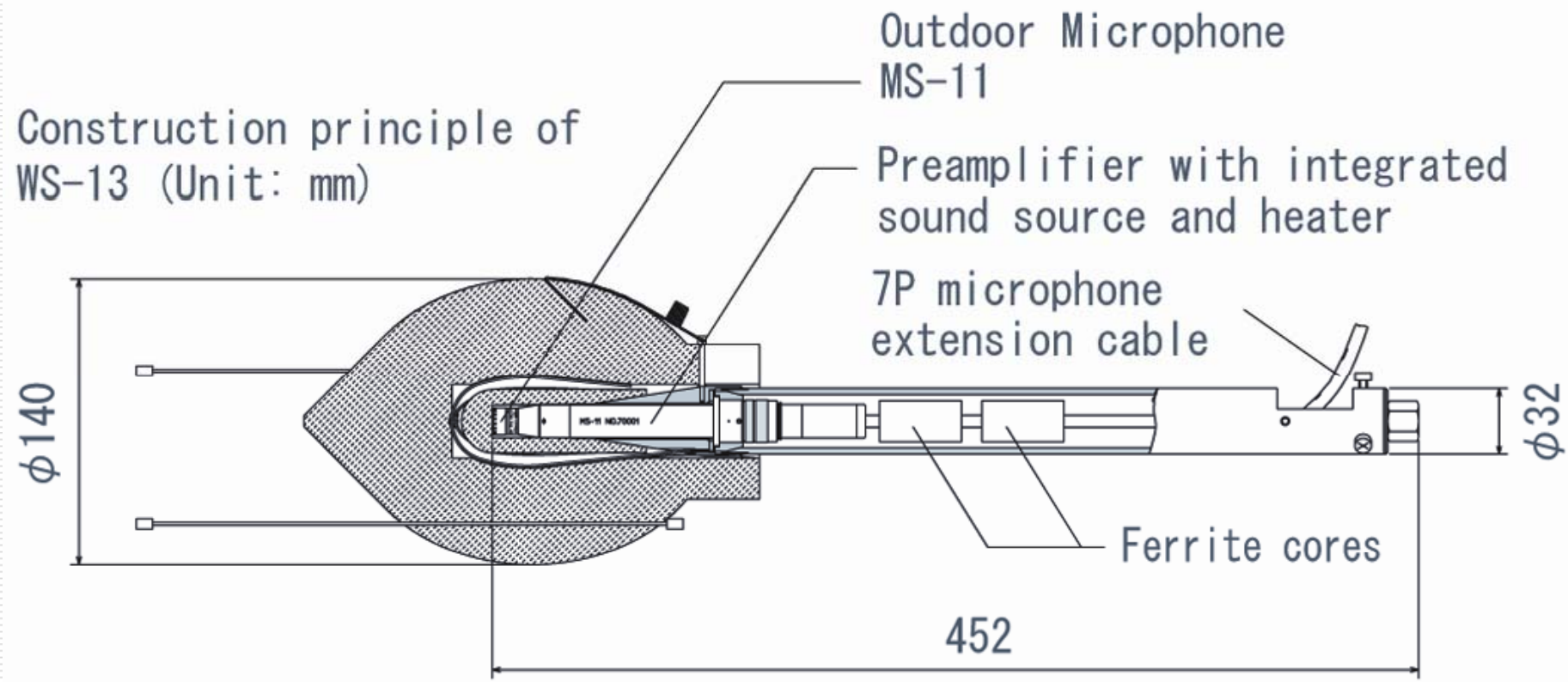


Suitable for long term outdoor noise measurements

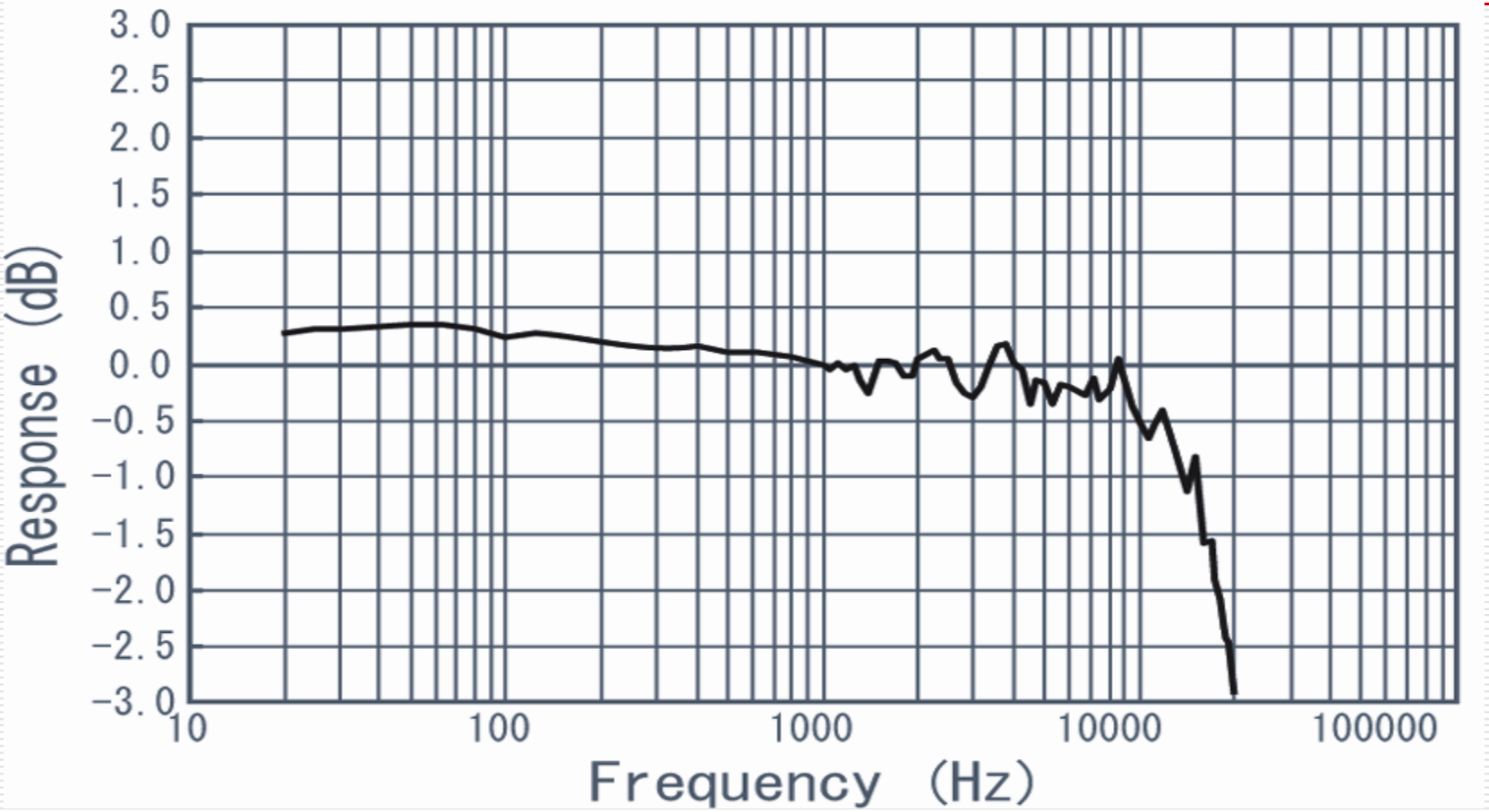
Microphone (MS-11) structure



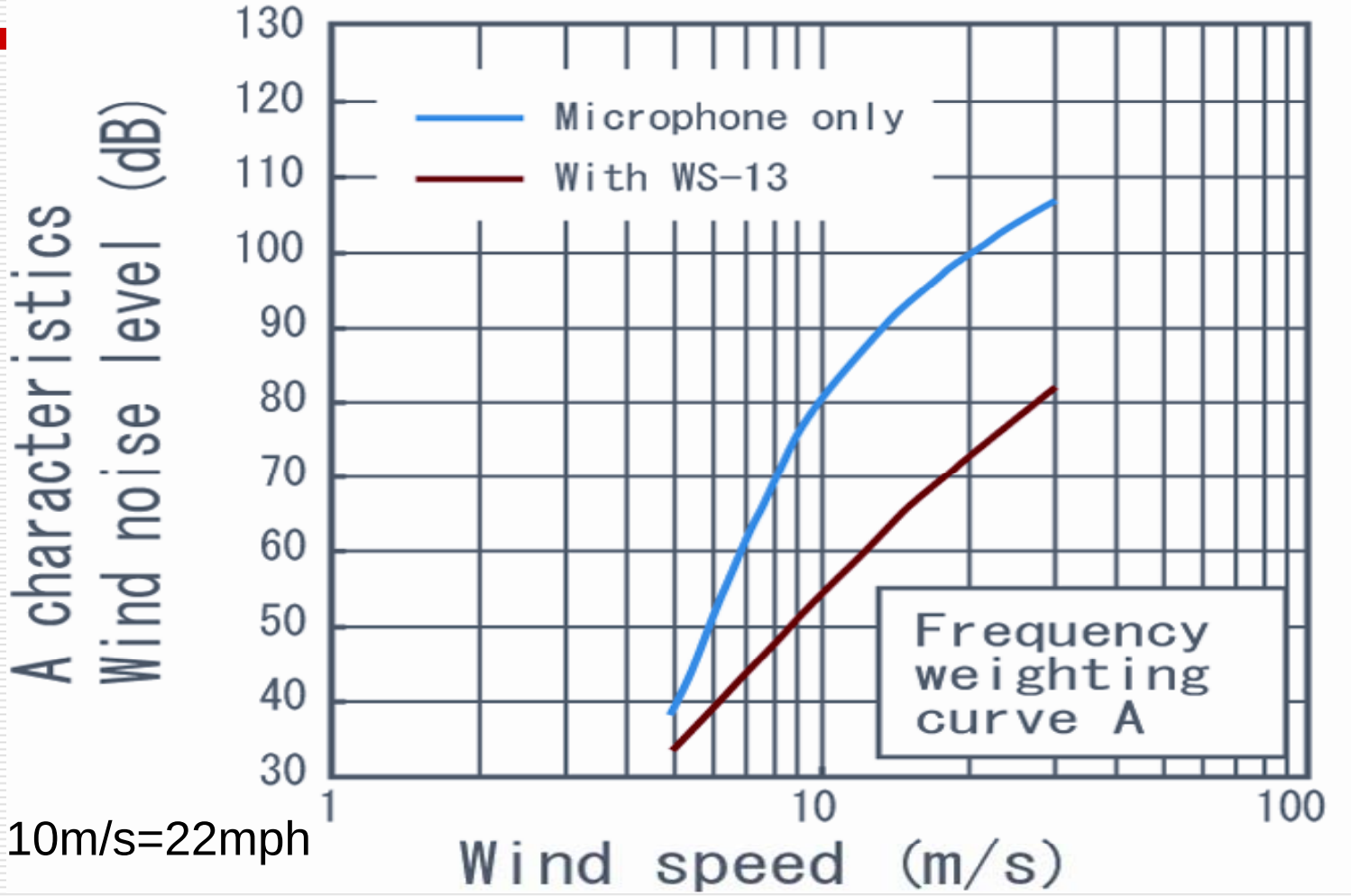
All-weather Windscreen Structure



Frequency Response with Windscreen



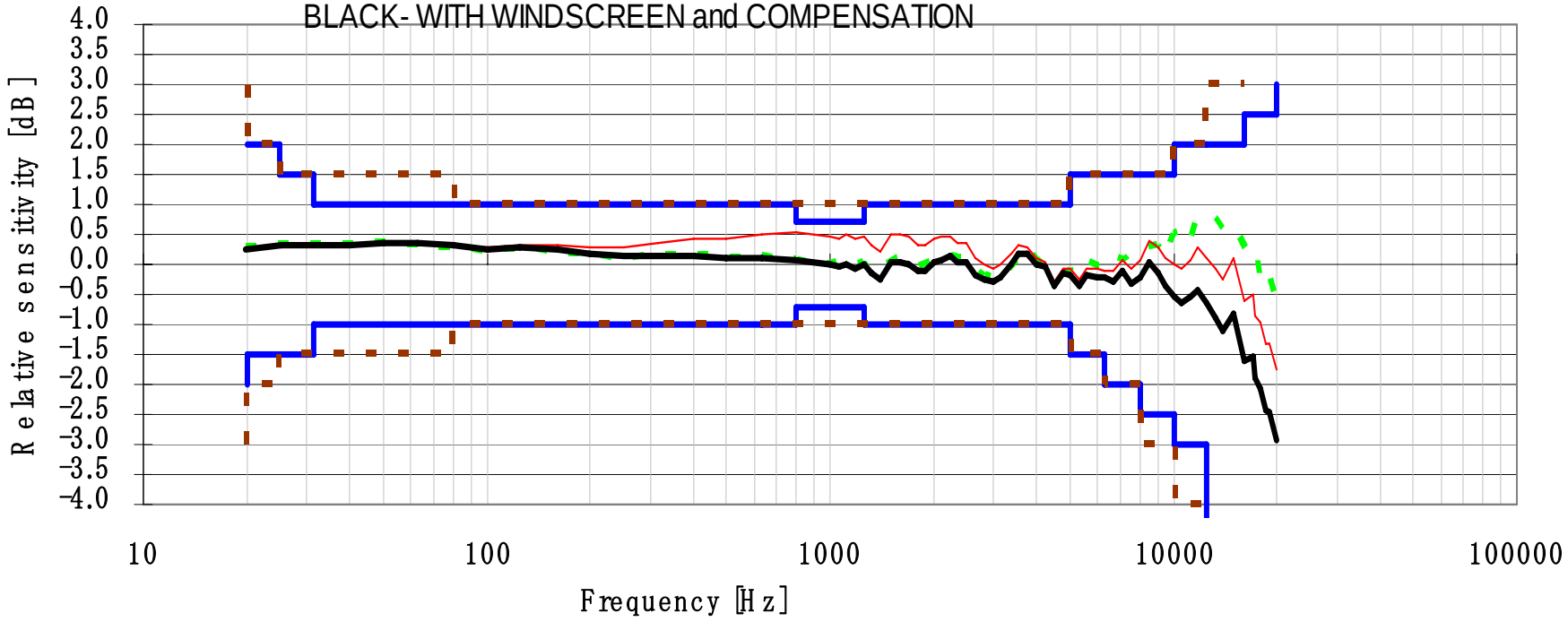
Wind noise Reduction-WS-13



10m/s=22mph

Overall Frequency Response

GREEN DOTTED- WITHOUT WINDSCREEN or COMPENSATION.
RED- WITH WINDSCREEN but WITHOUT COMPENSATION.
BLACK- WITH WINDSCREEN and COMPENSATION

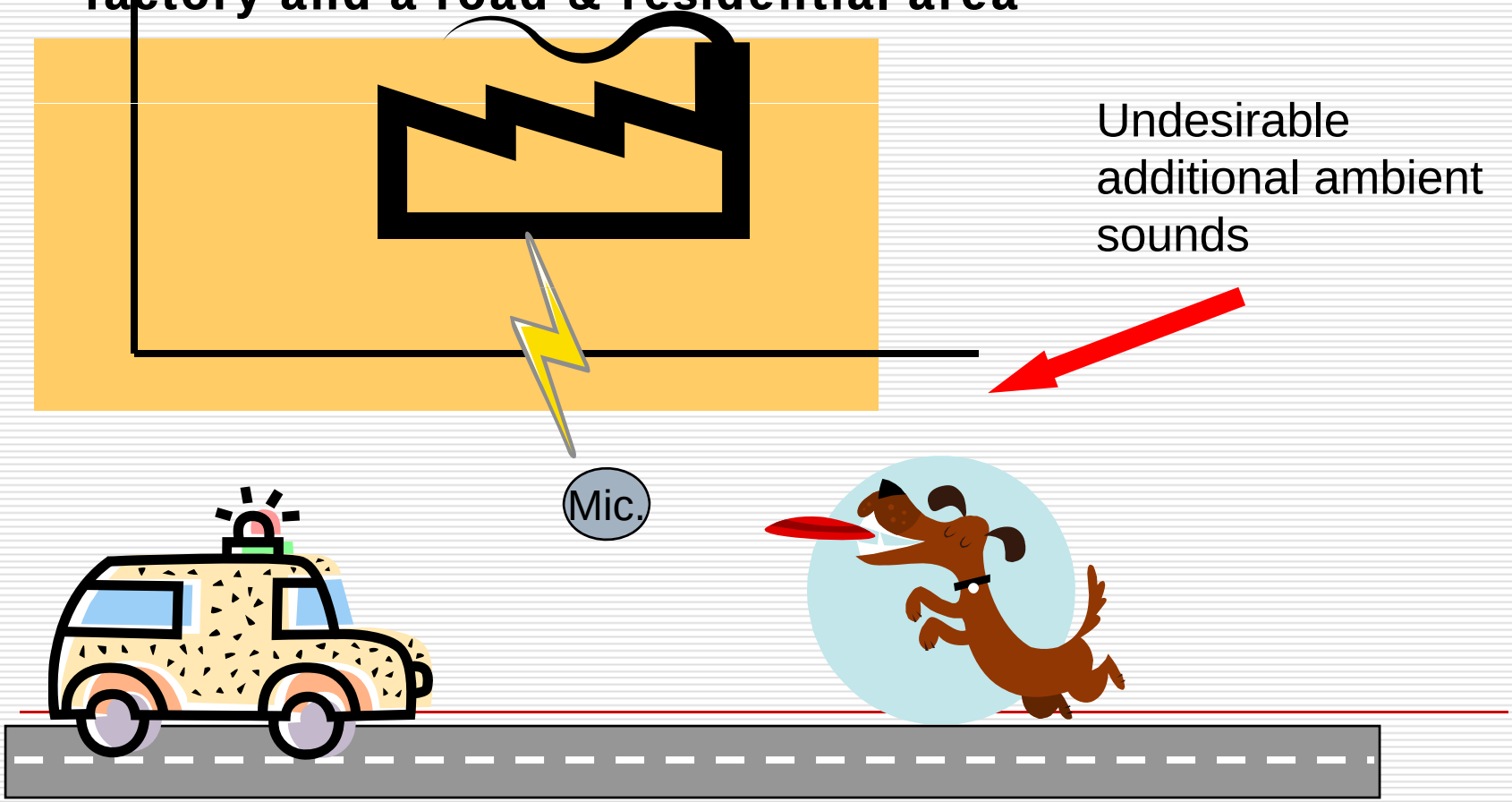


IEC61672-1 (JIS C 1509-1)周波数特性

Nominal frequency (Hz)	Exact frequency (Hz)	MS-11 Frequency Response (dB)	Electrical Response (dB)	Wind-screen effect (dB)	Wind-screen correction (dB)	Wind-screen combined (dB)	Total Response (Wind-Screen combined) (dB)	Total expanded uncertainty (dB)
63	63.10	0.3	-0.1	0.0	0.0	0.0	0.2	0.3
80	79.43	0.3	-0.1	0.0	0.0	0.0	0.2	0.3
100	100.0	0.2	0.1	0.1	0.0	0.1	0.2	0.3
125	125.9	0.2	0.0	0.1	0.0	0.1	0.3	0.3
160	158.5	0.2	0.0	0.1	-0.1	0.0	0.2	0.3
200	199.5	0.2	0.0	0.1	-0.1	0.0	0.2	0.3
250	251.2	0.1	0.0	0.2	-0.1	0.1	0.2	0.2
315	316.2	0.1	0.0	0.2	-0.2	0.0	0.1	0.2
400	398.1	0.2	0.0	0.3	-0.3	0.0	0.2	0.2
500	501.2	0.1	0.0	0.3	-0.3	0.0	0.1	0.2

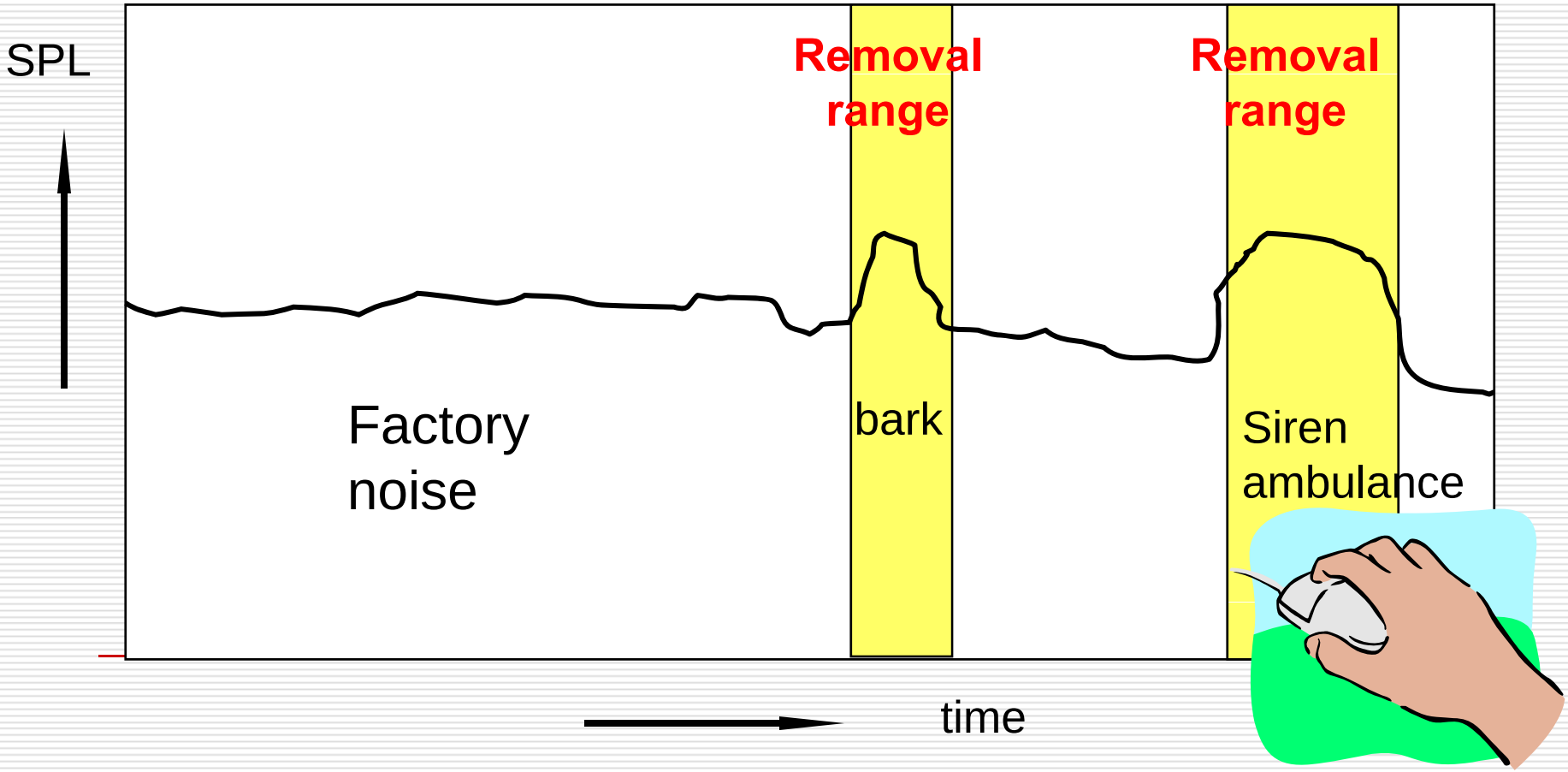
Issues of Environmental Noise Monitoring

For instance, noise monitoring at the boundary between a factory and a road & residential area



Manual Removal of Undesirable Sounds from Time History

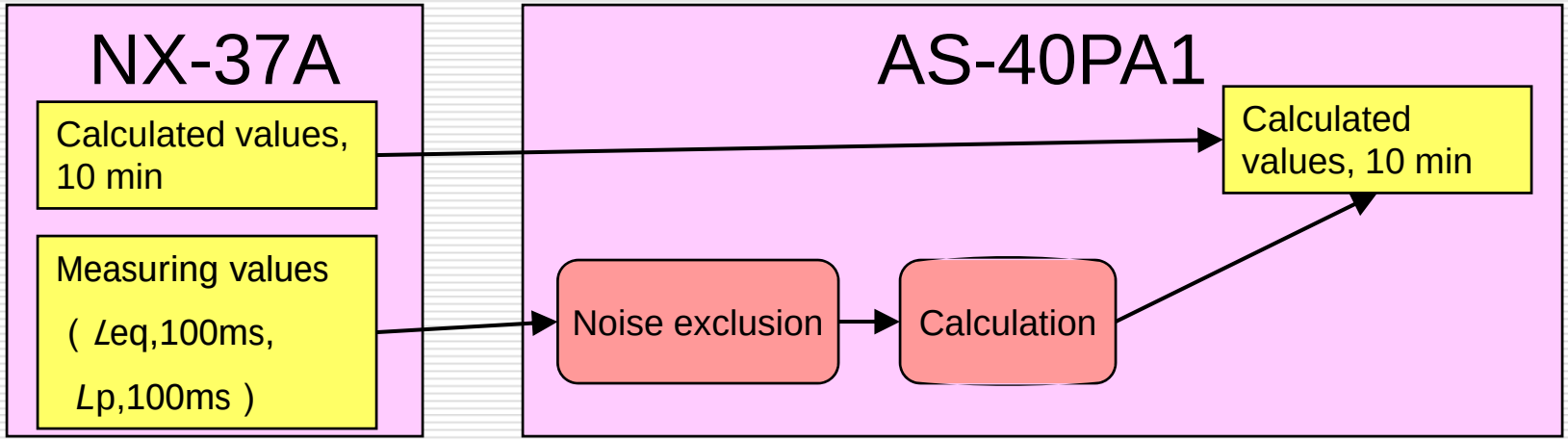
- Removal range can be determined by trend of the sound level and the nature of the sound.



Example- Calculated Values for 10 min

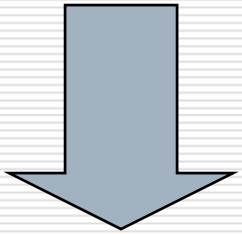
- Collected data are calculated from 10 min
  - *L*N1,*L*N2,*L*N3,*L*N4,*L*N5
  - *L*5,*L*10,*L*50,*L*90,*L*95
  - *L*eq,10min

- Calculated values are extracted from NX-37A
- When removing undesirable noises, data are recalculated from measured values.



Issue of Environmental Noise Measurements

* We want to remove undesirable sounds from objective sound source
* It is troublesome to remove undesirable sounds by listening to reproduced sounds.



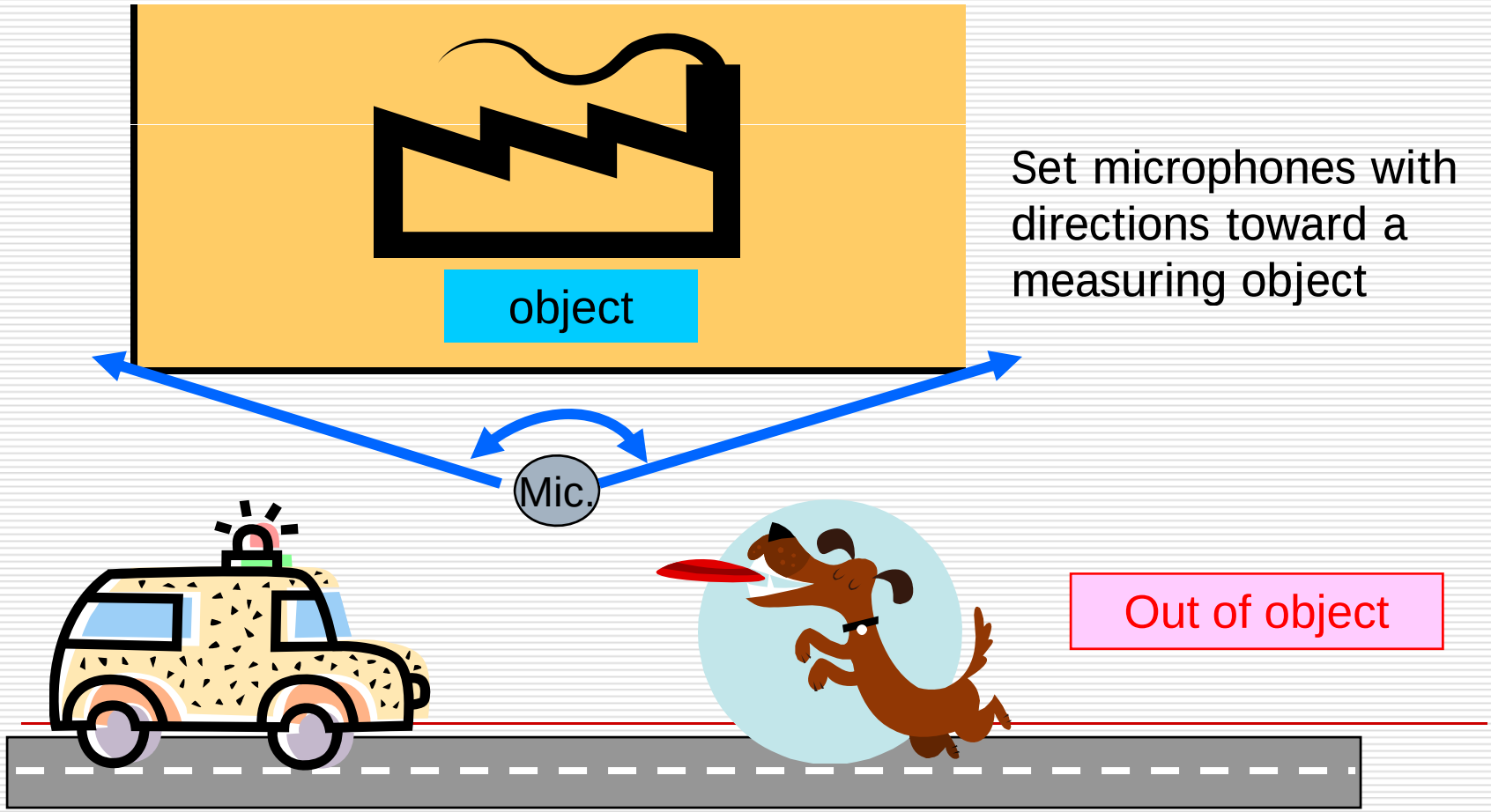
Undesirable sound sources = sounds comes from the other directions except that of objective sound.

We have automatic noise removal by sound direction

Direction Detection Microphones

Area Targeting

Objective sounds are distinguished by sound directions

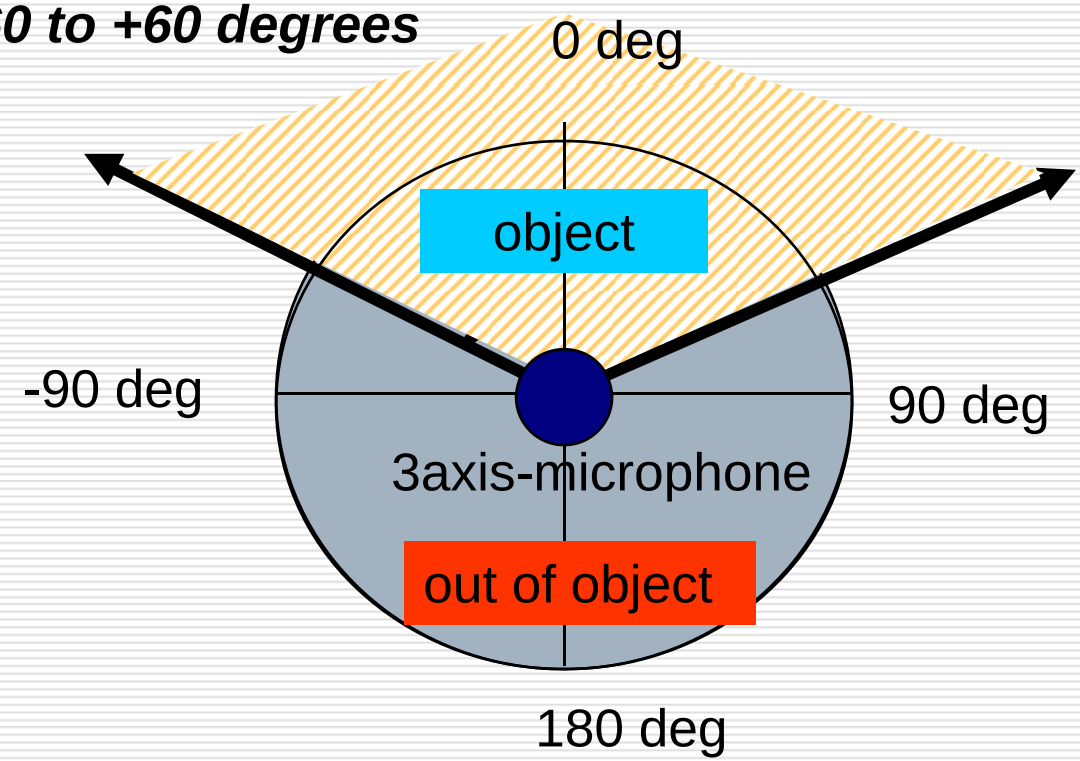


Set microphones with directions toward a measuring object

Setting Microphones Toward Object of Sound

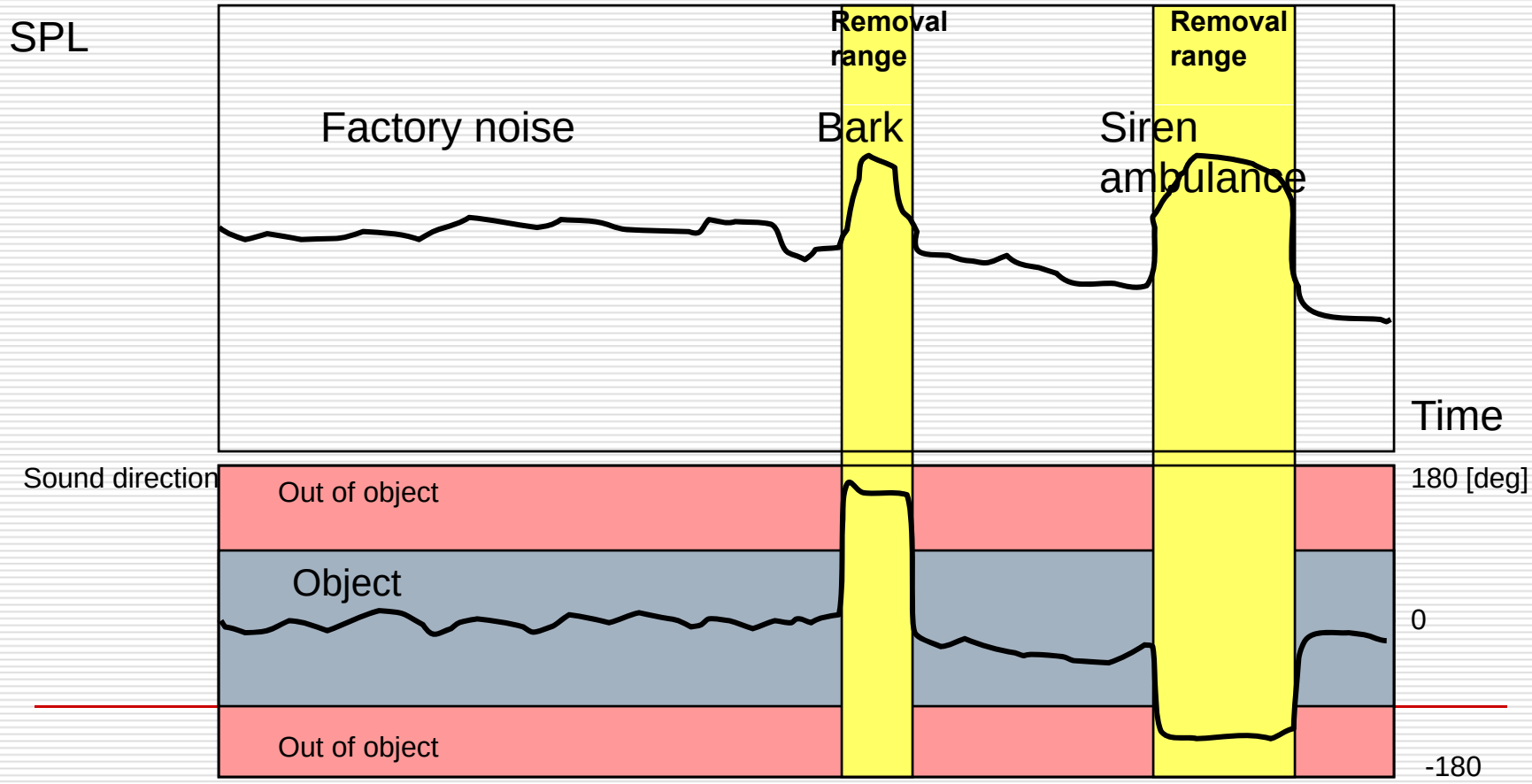
Specify area of direction angle (azimuth) into that of objective sound in horizontal plane

Example: -60 to +60 degrees



Method of Noise Removal

- Automatic removal of noises coming from the other areas and directions than objective area



Area Targeting

Make judgment of useful or useless data from sound direction in every 1 sec of LAeq

Example: validation range 0 deg to 100 deg

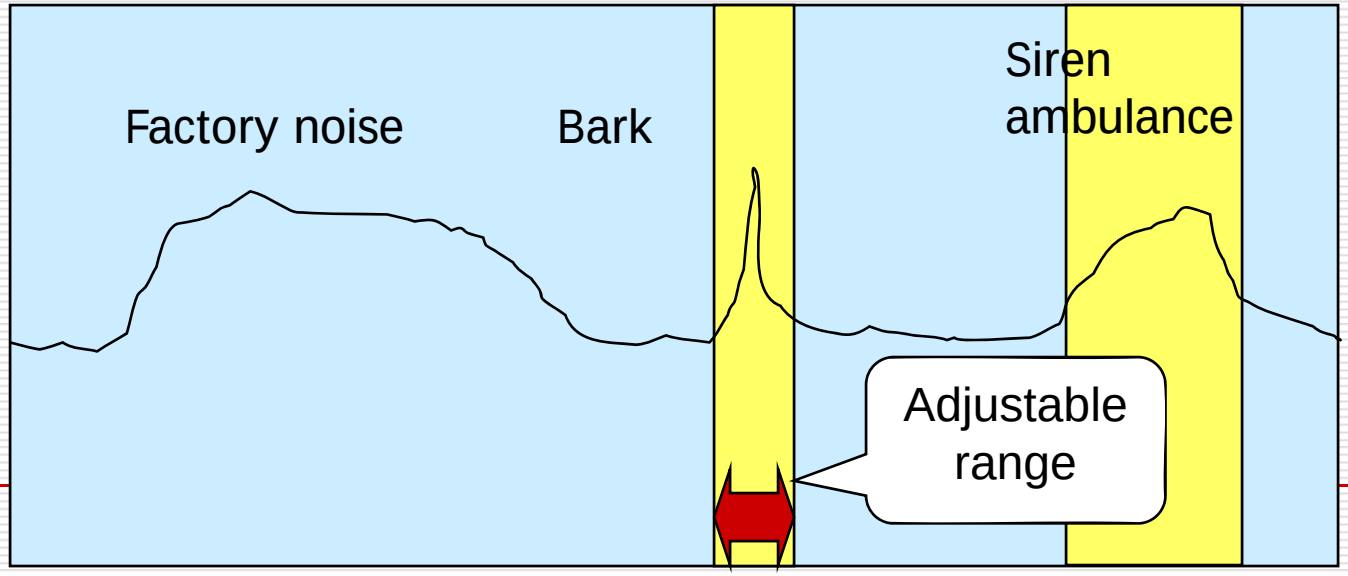
Time [hh:mm:ss]	$L_{Aeq,1sec}$ [dB]	Direction [deg]	Target
10:22:01	52.6	56	○
10:22:02	56.5	59	○
10:22:04	57.4	63	○
10:22:05	63.8	269	×
10:22:06	64.9	265	×
10:22:07	62.1	256	×
10:22:08	62.2	58	○
10:22:09	59.6	53	○
10:22:10	62.6	48	○

out of object

Editing of Measuring Values

Adjust any removal range exactly

Adjust useful/useless range in 1 sec steps on the measuring graph

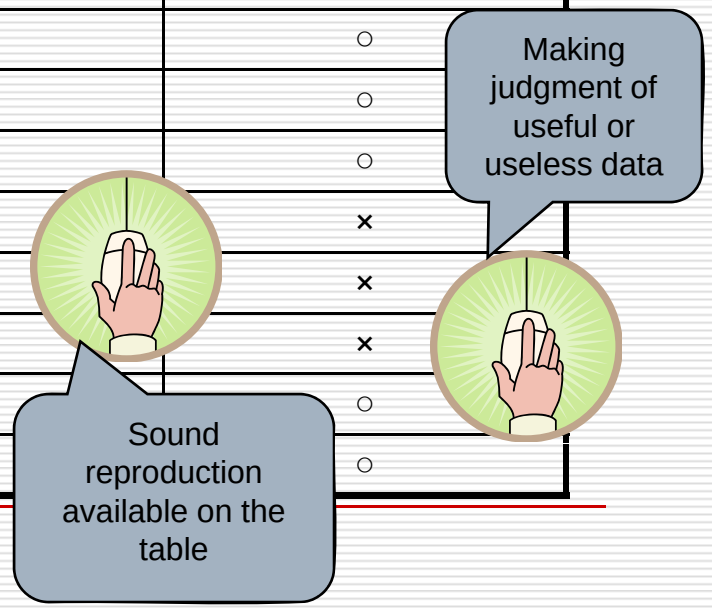


Editing of Calculated Values

By checking calculated values on a list of collected data and listening to the recorded sounds, users make judgment of useful or useless data.

To easily remove calculated value including abnormal noises

Time	$L_{eq,10min}$ [dB]	Sound Files	Judgment
10:00:00	52.6	1	○
10:10:00	56.5	0	○
10:20:00	57.4	3	○
10:30:00	63.8	0	×
10:40:00	64.9	0	×
10:50:00	62.1	1	×
11:00:00	62.2	1	○
11:10:00	59.6	2	○



Microphones for Detection of Direction

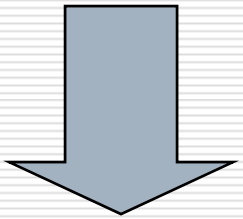
AN-37 detects a direction of the sound source.

- Tri-axial microphones
- Compact device (25 cm interval from a center pole)
- Weather resistant

The direction data is used for exclusion of *some* noise sources.

Directional Data of Sound Source

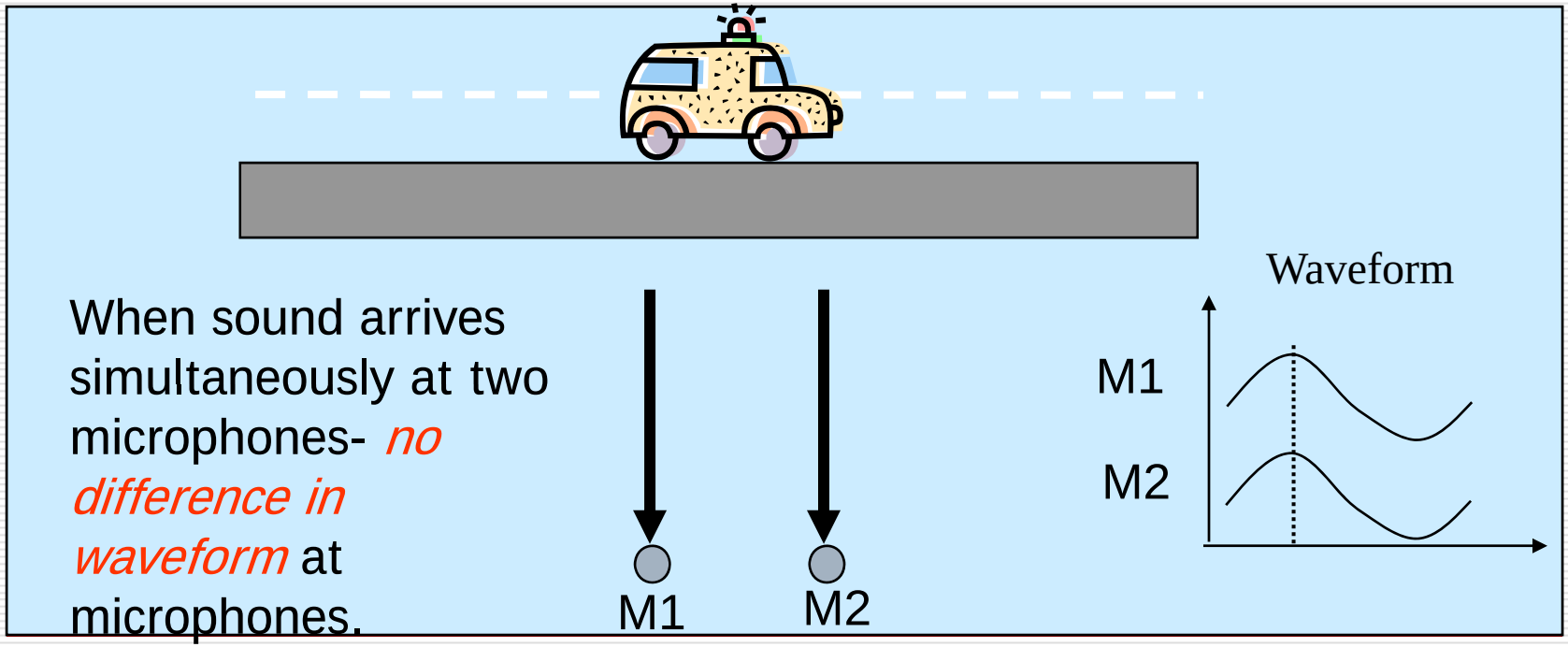
- Directions of sound sources are detected by tri-axial microphones every second.



The data are used to locate and identify sounds in a specified direction.

Detection of Sound Direction

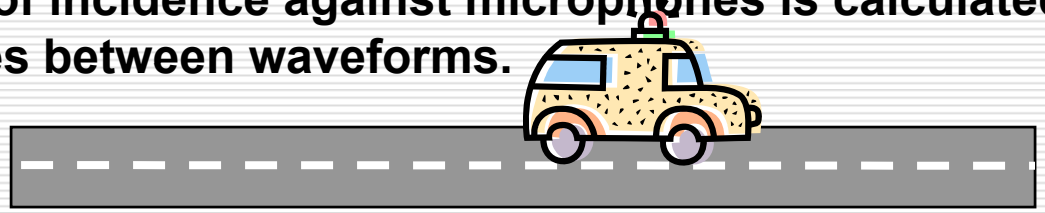
Principle- We make use of time difference of which two microphones receive a sound. We can get angle against the sound source from the time difference.

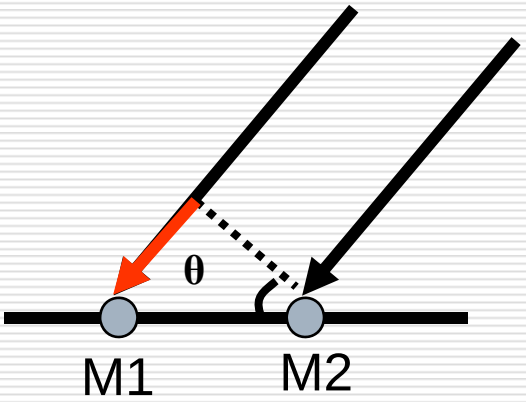


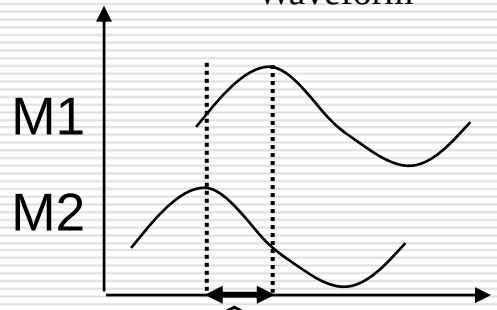
Detection of Sound Direction

Arrival time differences of a sound at microphones will occur except when the sound reaches the microphones simultaneously.

An angle of incidence against microphones is calculated from time differences between waveforms.



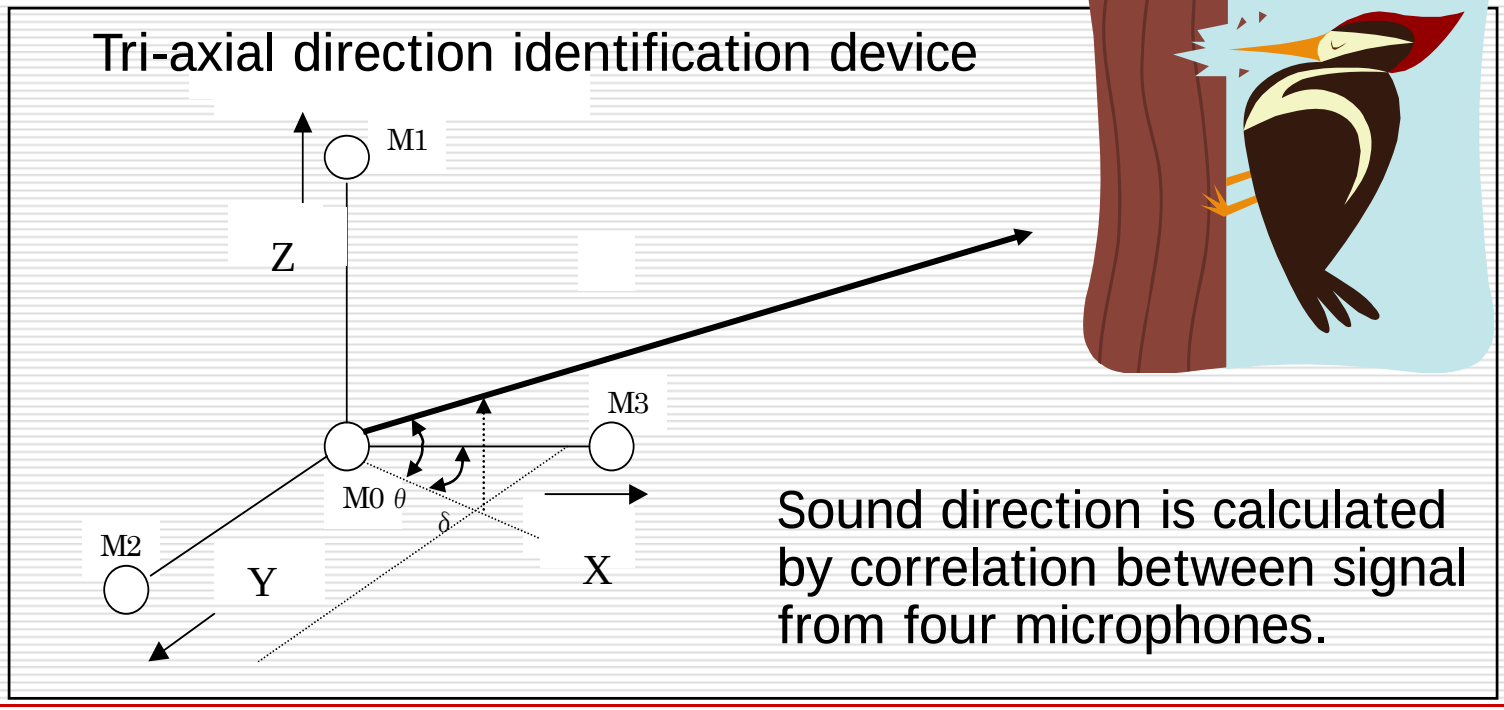


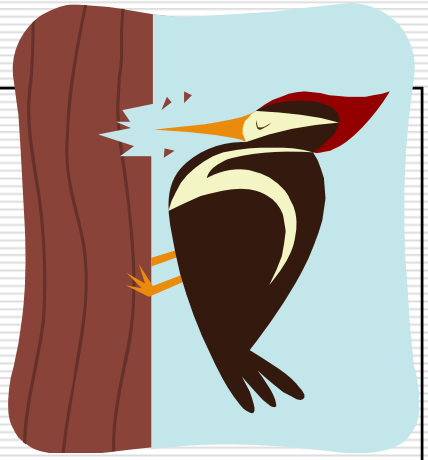


Angle, θ, is calculated from the time difference, t.

Direction of Sound

Tri-axial microphones enable three-dimensional detection of sound direction (elevation and direction).



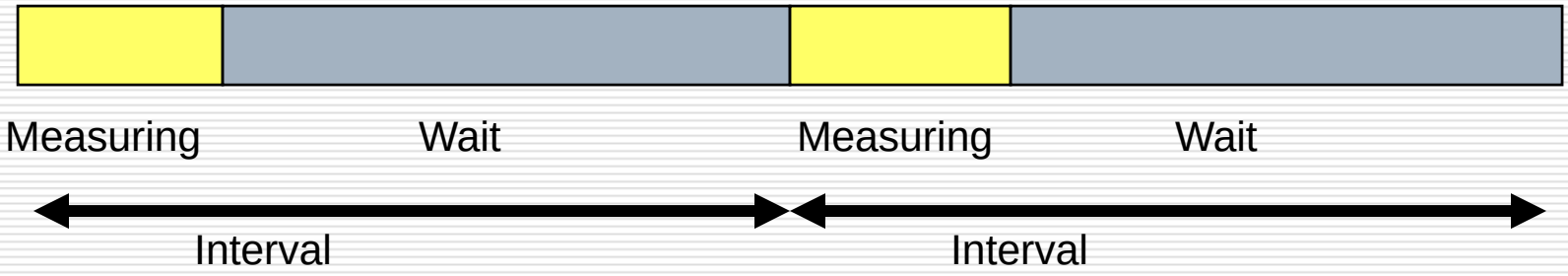


Software for Review and Analysis

Calculations of L_{eq}, L_N

- Interval mode

  Repeats measuring the first part of regular intervals

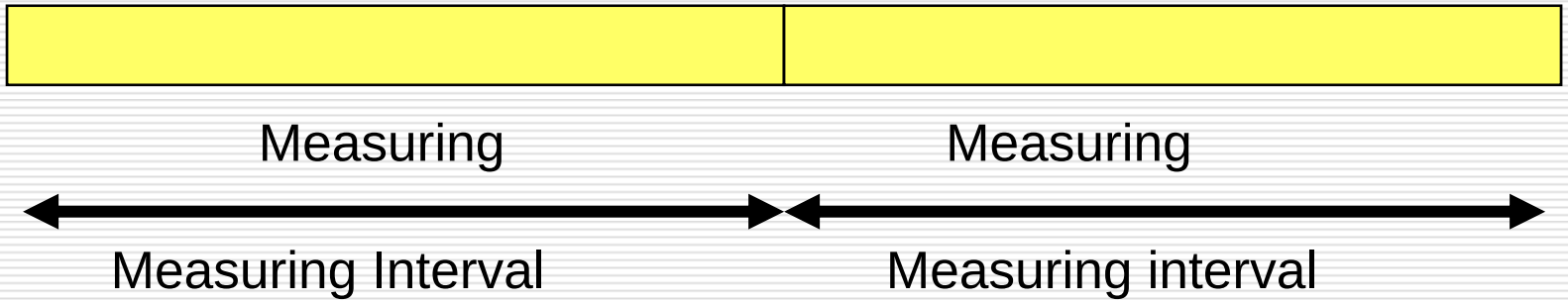


For example, we measure the first 10 min for every 1 hour.

Calculations of *L*eq, L_N

- Continuous mode

  Continuously measurement in every measurement interval



For example, we continuously measure every 1 hour.

Various data are extracted from NX-37A

- Calculated values (Data that are calculated under NX-37A)
  - L_{N1},L_{N2},L_{N3},L_{N4},L_{N5}
  - L_5,L_{10},L_{50},L_{90},L_{95}
  - $L_{eq,10min}$
- Measured values (Original data that are used for calculated values)
  - $L_{eq,1sec}$
  - $L_{eq,100msec}$
  - $L_{p,100msec}$
  - Sound direction in every 1 sec.
- Sound recording files (MP3 or WAV)
- Other data for administration

AS-40PA1 Function

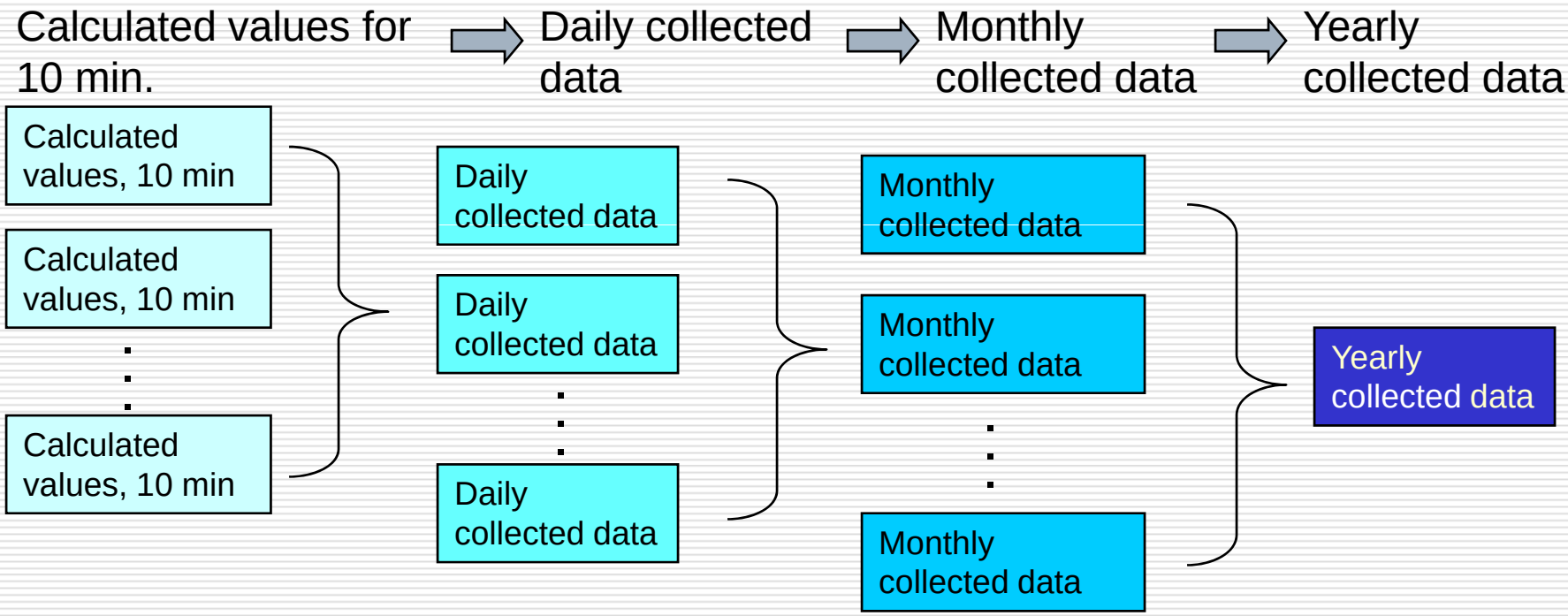
Data make available

- Measuring data are made up in accordance with measuring values and calculated values periodically.
- Lists of calculated values are available
  - Daily
  - Monthly
  - Yearly

Function of AS-40PA1

- Collected data
  - Percentile sound level L5,L10,L50,L90,L95
    - Every hour
    - Every day
  - Equivalent continuous sound level *L*eq
    - Every hour
    - Every day
  - Equivalent continuous sound level with time periods
    - *L*eq,day, *L*eq,evening, *L*eq,night
    - *L*dn (calculated with two periods)
    - *L*den (calculated with three periods)

Flowchart of AS-40PA1 Data Availability



Cumulative collected data are calculated from the previous collected data.

Conclusions

- Flexible
- Combines sound, meteorological, and location data with accurate timing
- Sound can be saved
- Automatic or manual exclusion of non-important events
- Data retrieval by LAN, Wirelss, Thumb drive

Requirements for environmental sound monitor system

- Stability operation for long term.
  - Stability operation of microphone in harsh outdoor location.
  - Operation guarantee when power outage.
  - Notification to server when abnormality occurs.
- High reliability of measured data.
  - Identification of targeted noise and manual or automatic removal of extraneous noise
  - The re-analysis and the post-processing of the measured data should be able to be done easily.

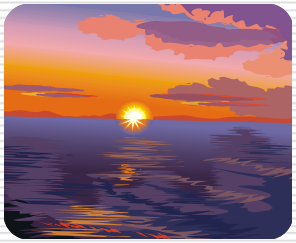
DAY-EVENING-NIGHT Metrics Can be Calculated

*L*dn

Dividing one day into two time periods (day and night), and calculated with *L*eq

*L*den

Dividing one day into three time periods (day, evening, and night, and calculated with Leq.



Reference Function of AS-40PA1

- List of collected data
- Graph of collected data
- Printout of lists
- Export data in text file
- Replay of sound

Environmental Noise Processing Program NX-37A

- Calculated data (*L*eq, *L*N)
  - Interval mode and continuous mode
  - Sampling interval: 0.1 to 10 sec.
  - Measurement time: 0.5 sec to 24 hours
- Measurement data
  - *L*eq,1sec
  - L_{DEN} / L_{DN}
  - Direction data in every 1 sec
  - Weather data
  - Daily reports
  - Weekly reports
  - SPL every 100ms
  - Directional vector every 200ms
- Sound recording (Option NX-37WR)
  - Level trigger, Interval trigger, manual trigger
  - File format: MP3/WAV

Software for Results (XP or Vista)

Software to allow

-a simple method to collecting measurement data

-show results of measurements.

- It controls and sets-up NA-37
- Automatic data processing
- Allows data collection (manual or automatic)
  - On-line collection (LAN)
  - Off-line collection (when using USB memory).
- Allows maintenance by administrator

Features

Options available to extend NA-37 functions

- Automatically adjust clock
  - Auto time adjustment function
- Automatically record measuring coordinates
  - With GPS module.
- Check data at measuring site
  - Print-out function (When using USB printer)
- Receive and log weather information
  - Meteorological data logging function
    (When using an exclusive meteorological meter)

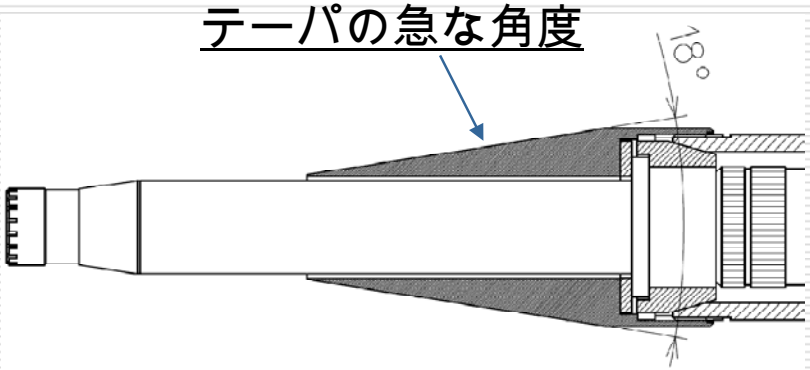
Sound Recording

- **Trigger recording**
  - Level trigger: records sounds above a set threshold level
  - Interval trigger: records sound periodically
  - Manual trigger: when “START” is pressed
- **File format**
  - MP3: Stores massive amount of data because stored data are compressed.
  - WAV: Higher quality but takes more memory than MP3 format.
- **Recording time 5 to 60 sec when using level trigger, each stored separately.**
- **Internal memory has a capacity to store data for 40 days. (MP3 format, 5 sec, 1000 events in a day)**

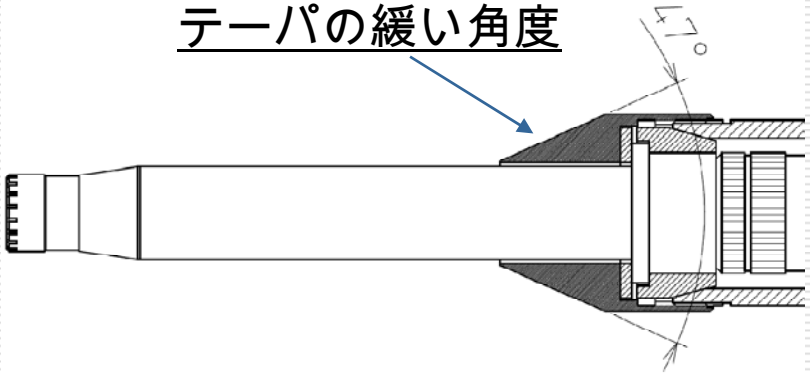
3-1 ウィンドスクリーンの性能

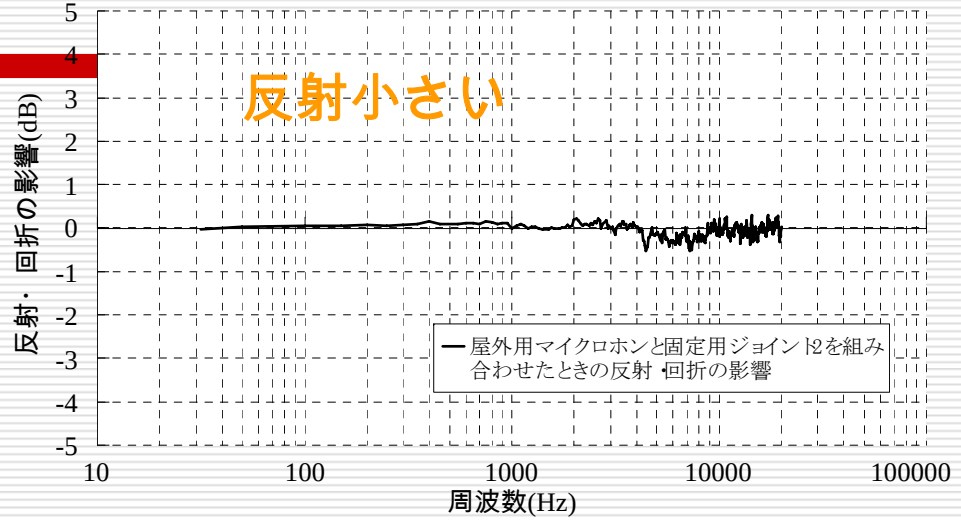
取付面の音響反射の影響

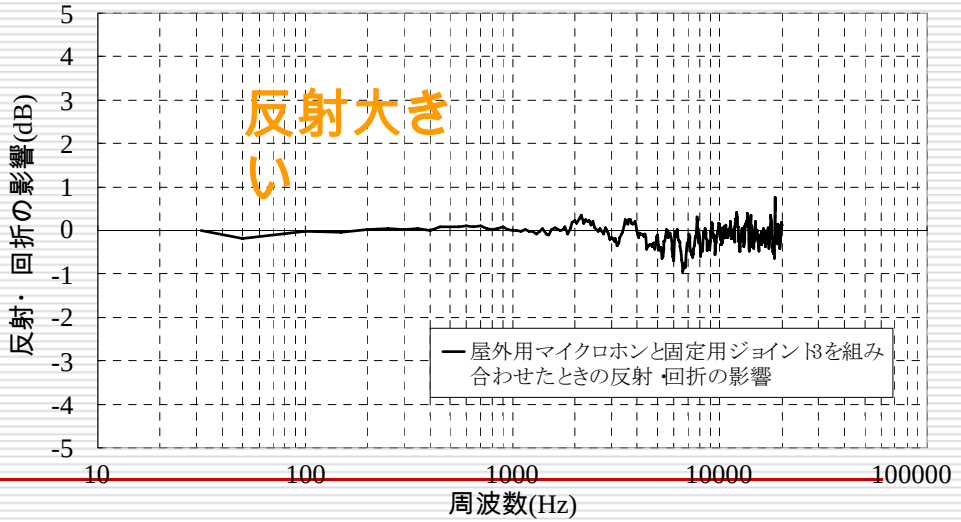
テーパの急な角度



テーパの緩い角度



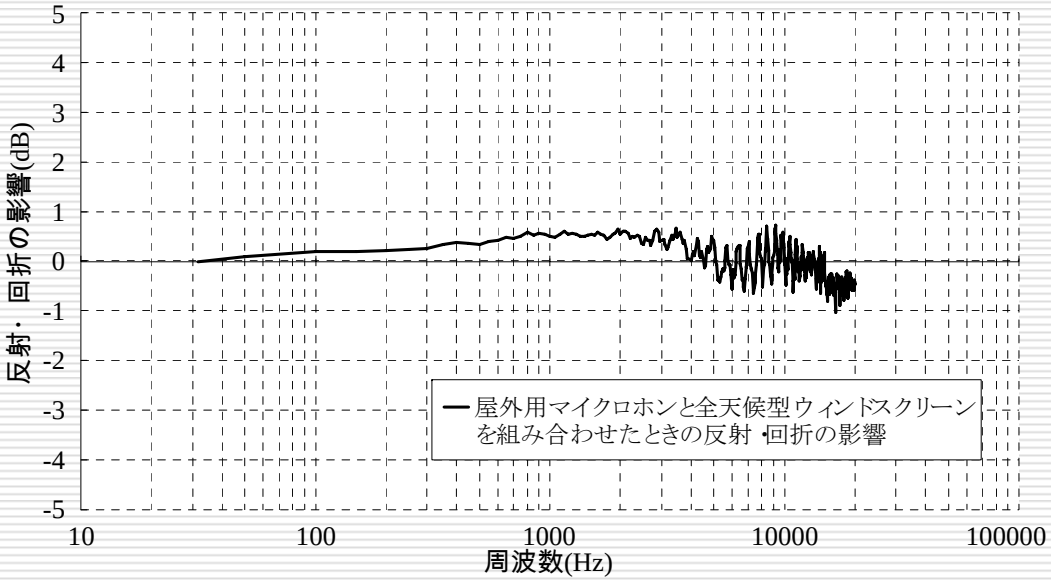




3-1 ウィンドスクリーンの性能

ウィンドスクリーンによる音響性能への影響

防風材料、防雨材料による音響特性



マイクロホンにウィンドスクリーンを装着時の正面入射音響特性

Function of AS-40PA1

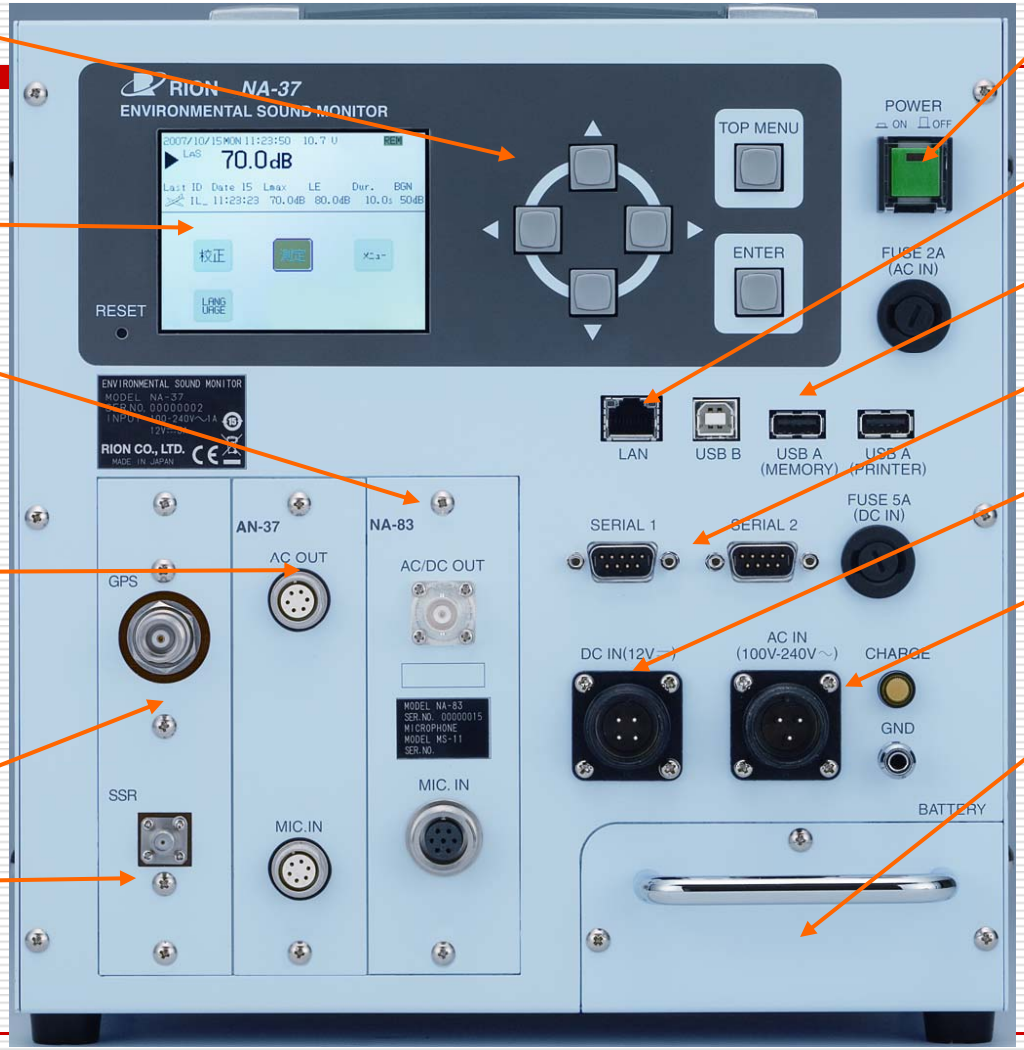
Dividing the useful from the useless data

- From all data collected
  - Making up useful data
  - Making up useless data

The RION Environmental Noise System

- Environmental Noise Monitor
  - Environmental Noise Processing Program [NX-37A]
  - Sound Level Meter (Class 1) [NA-83]
  - Noise Identification Unit (to detect a direction from sound source) [AN-37]
- Data Processing
  - Environmental noise data processing software [AS-40PA1]

Overview of the NA-36 system



Operation Keys

Color LCD

Sound Level Meter NA-83

Identification Unit AN-37

GPS module

SSR Receiver AN-37R

Power Switch

LAN

USB

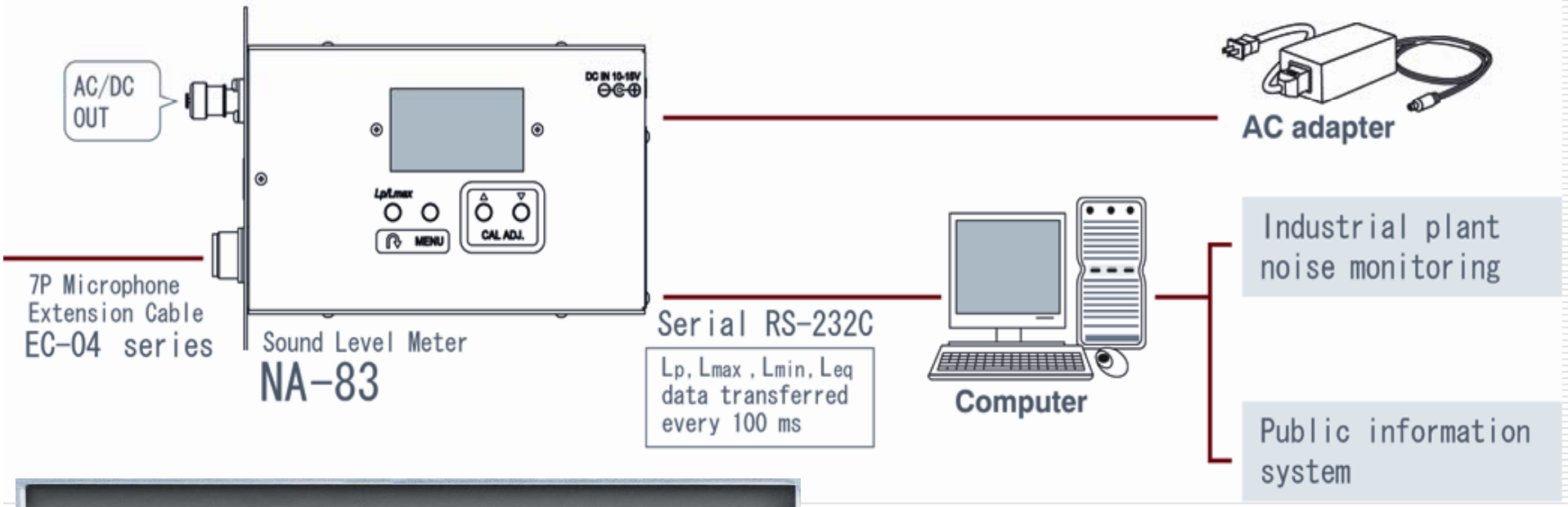
RS-232-C

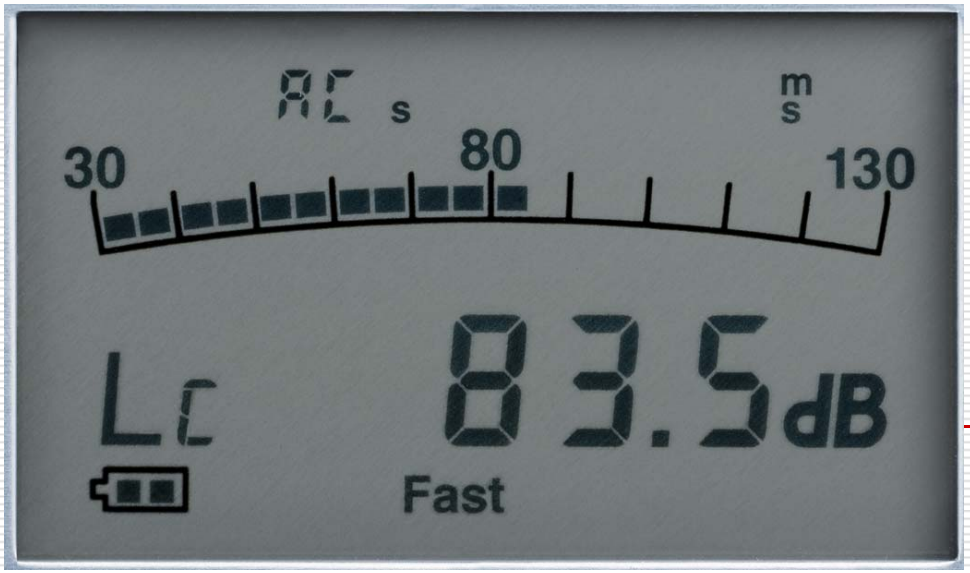
DC Power

AC Power

Battery Unit

Sound Level Meter NA-83 for NA-37 (2)

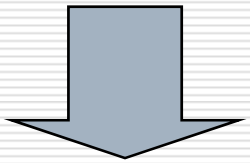




System configuration

Features of NA-37

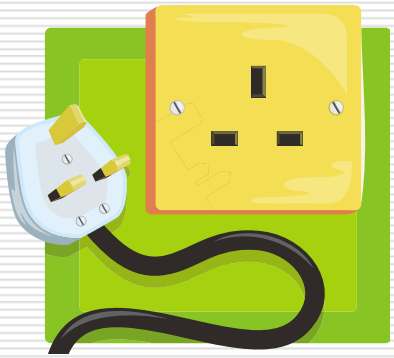
- Sound Level Meter section NA-83
  - Applicable to IEC 61672-1 Class1
  - CE marked
  - Applicable for Japanese Measurement Law, Japanese homologation system, type approval and accepted in all countries
  - Single, large dynamic range 110 dB



Applicable to requirements of local laws and regulations

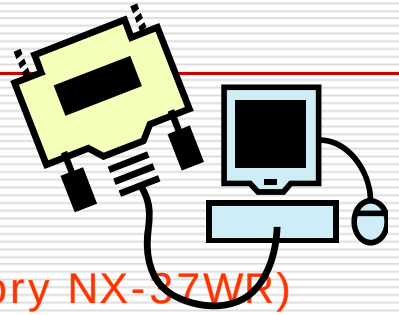
Features of NA-37

- Measures against power failure
  - Internal battery to run it at least 2 hours
  - Optional external battery
  - Auto-shutdown and auto recovery



It allows operation in areas with non uniform power supply

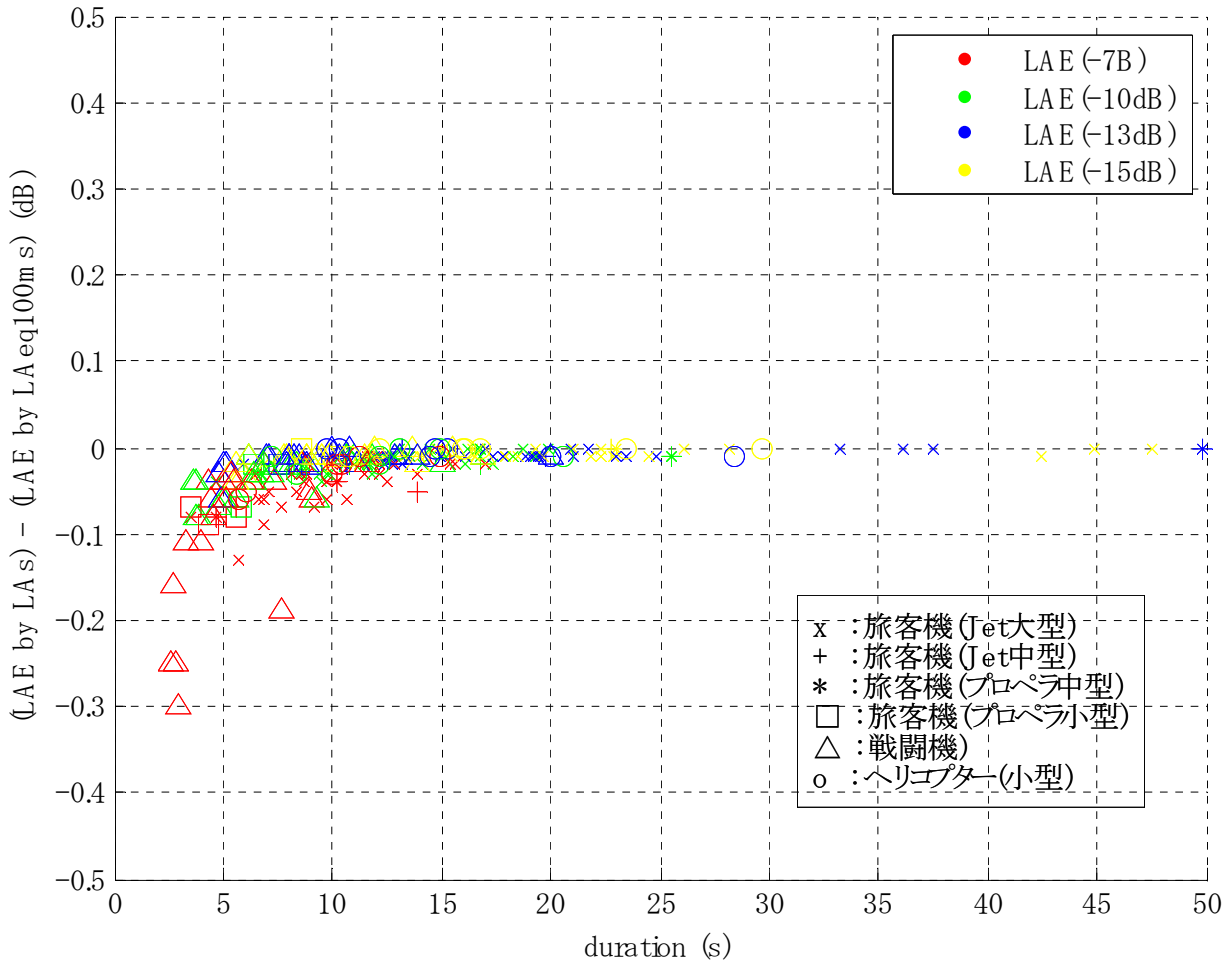
Features of NA-37



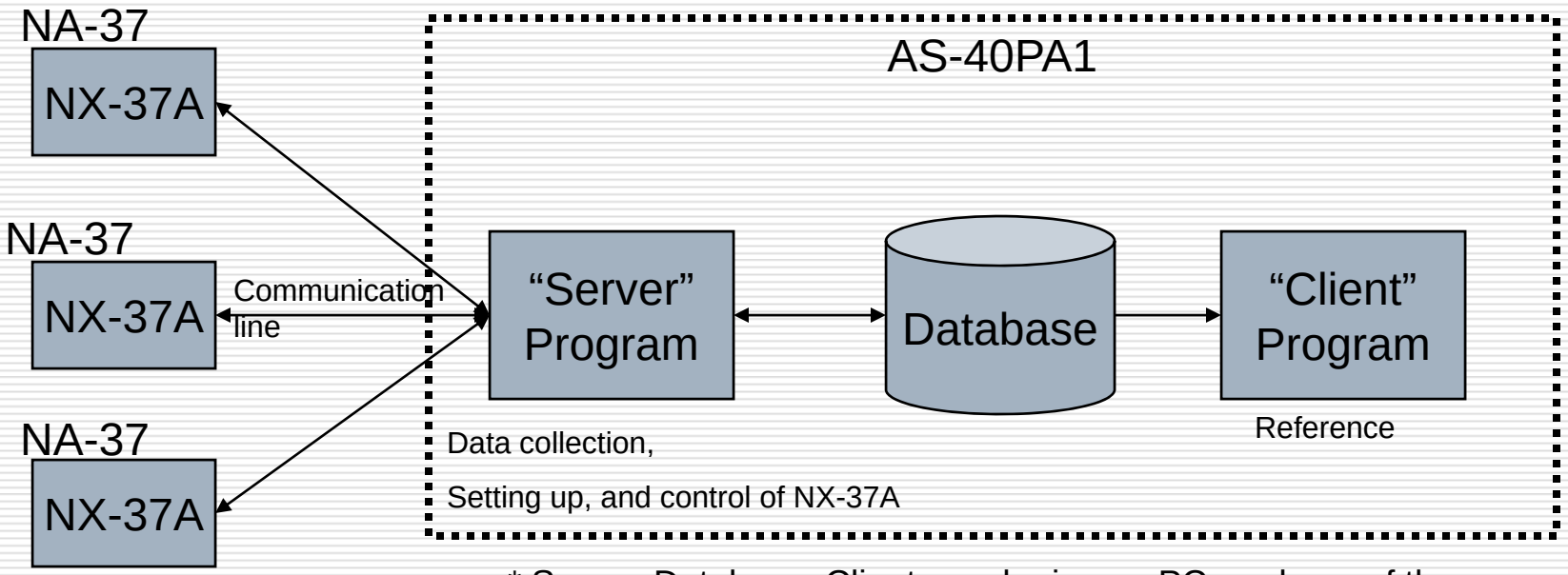
- Communication interface
  - LAN
  - RS-232-C
  - Modem (through analog public line)
- Sound recording functions (when using optional accessory NX-37WR)
  - MP3/WAV format
  - Level trigger/interval trigger
- Massive internal memory capacity
  - E.g. 40 days with 1,000 events/day and sound recording with NX-37WR and MP3 format (in 5 sec sampling)
- Data extraction
  - On-line communication
  - USB memory stick available

5. L_{AE}の算出

L_{AE}の計算方法及び騒音イベント検出区間の違いによるレベル差



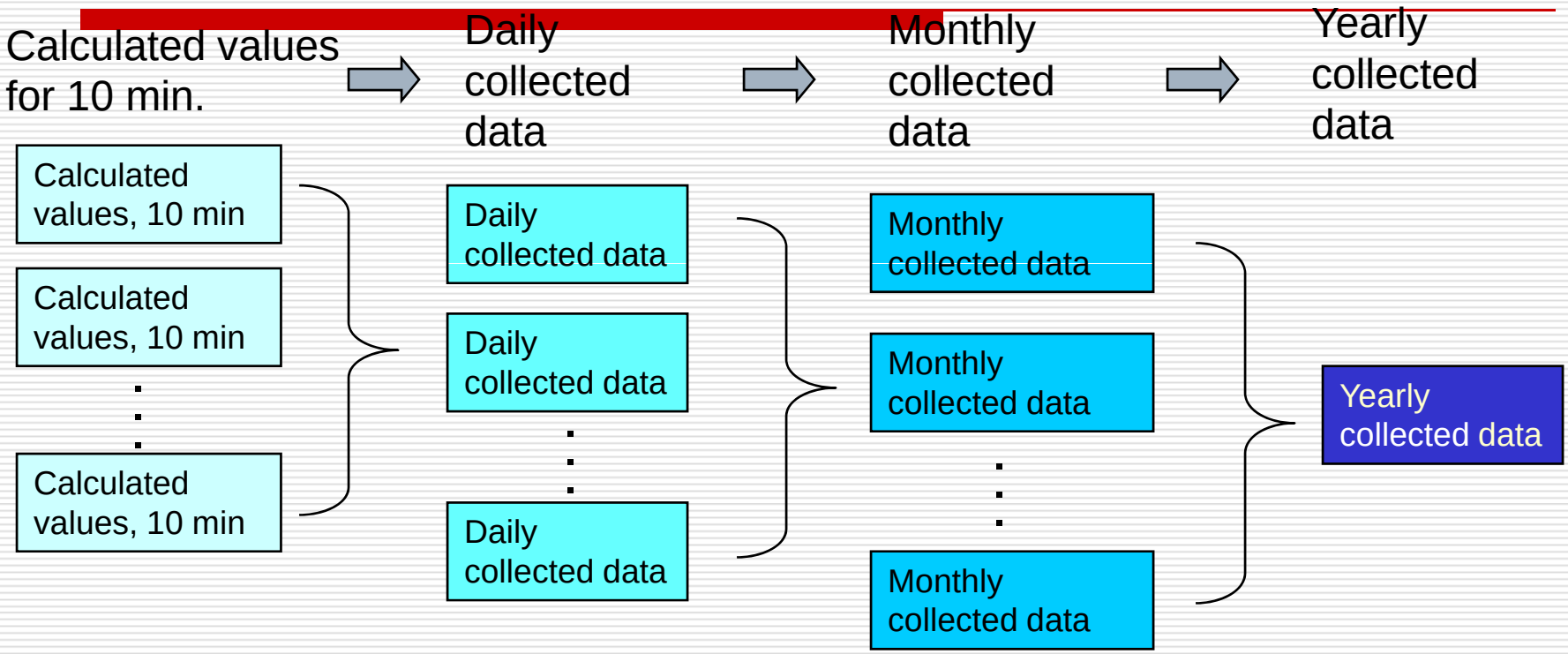
AS-40PA1 System Diagram



* Server, Database, Client, can be in one PC, and one of them can be in the other PC if necessary.

* One license covers 3 Clients.

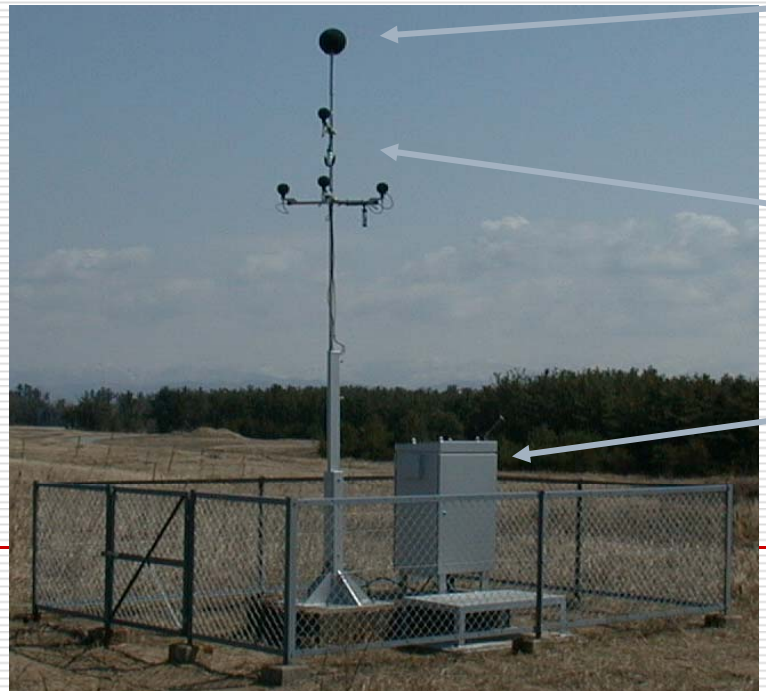
owchart of AS-40PA1 Data Availability



Cumulative collected data are calculated from the previous collected data.

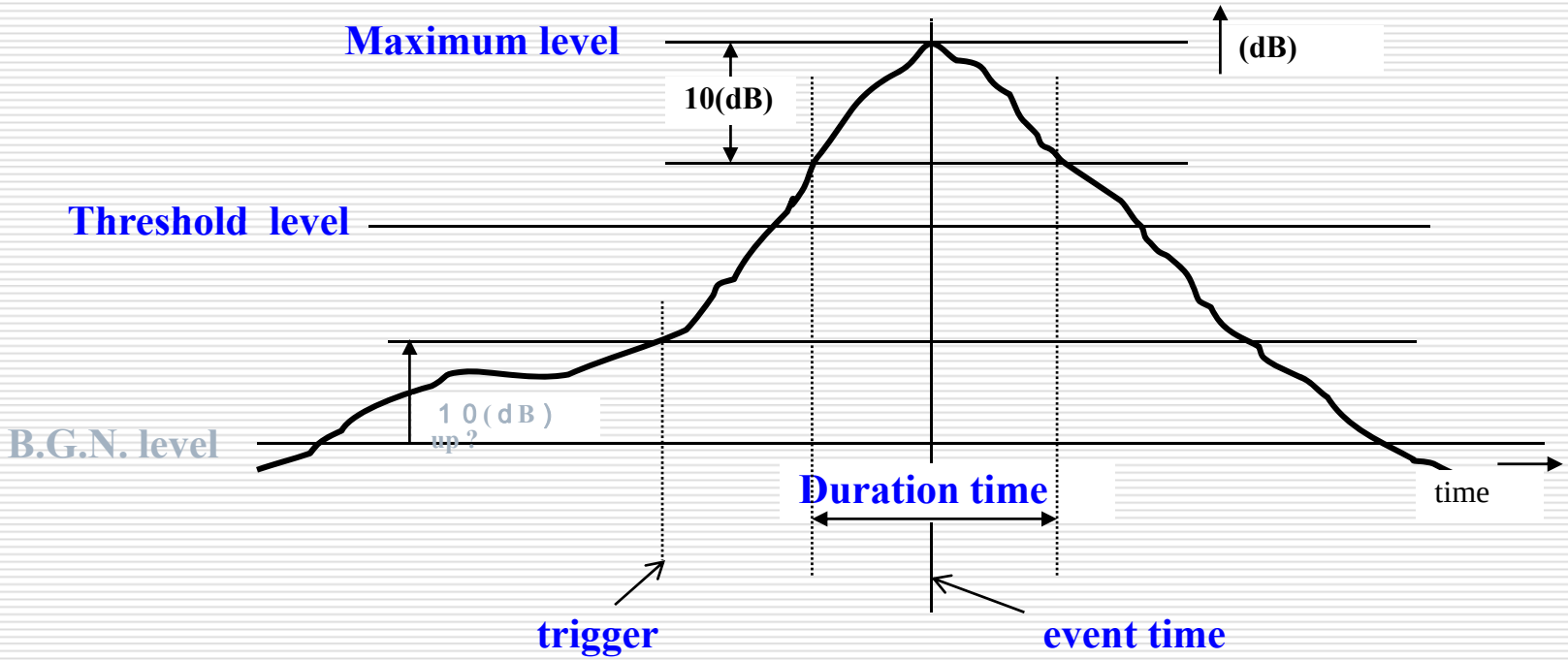
Aircraft noise processing program
NX-37B

- Automated aircraft sound identification
  - Automatic sound event detection
  - Sky sound detection by elevation angle data calculated by 2 microphone used correlation method
  - The distance of an aircraft is detected by receiving the intensity of a radar signal level

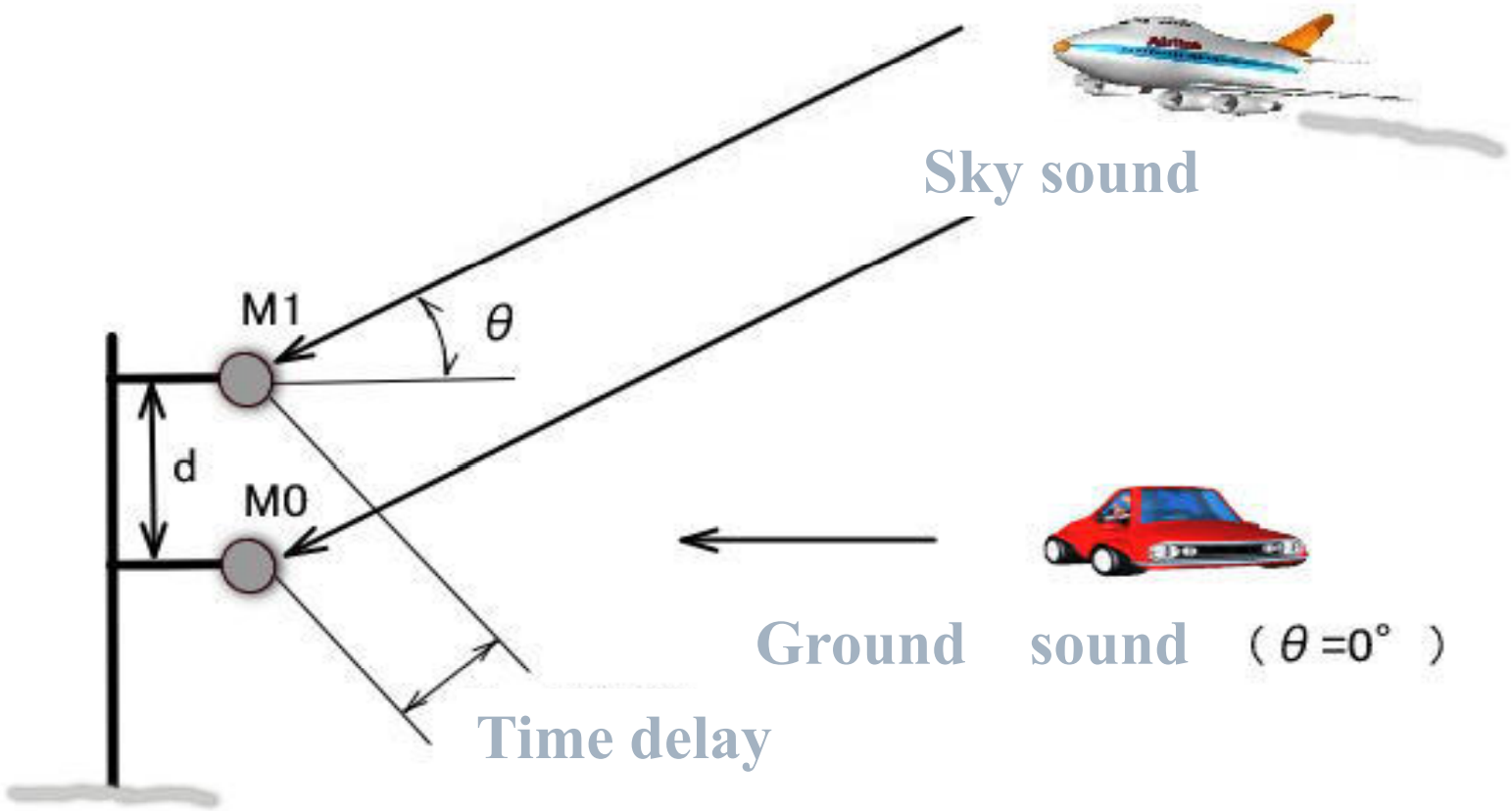


Detection of peak noise event

- Detection procedure
  1. **When a L_{AS} level exceed the B.G.N plus 10dB.**
  2. **When a Maximum level exceed the threshold level.**
  3. **When a Duration time exceed the specified time threshold.**



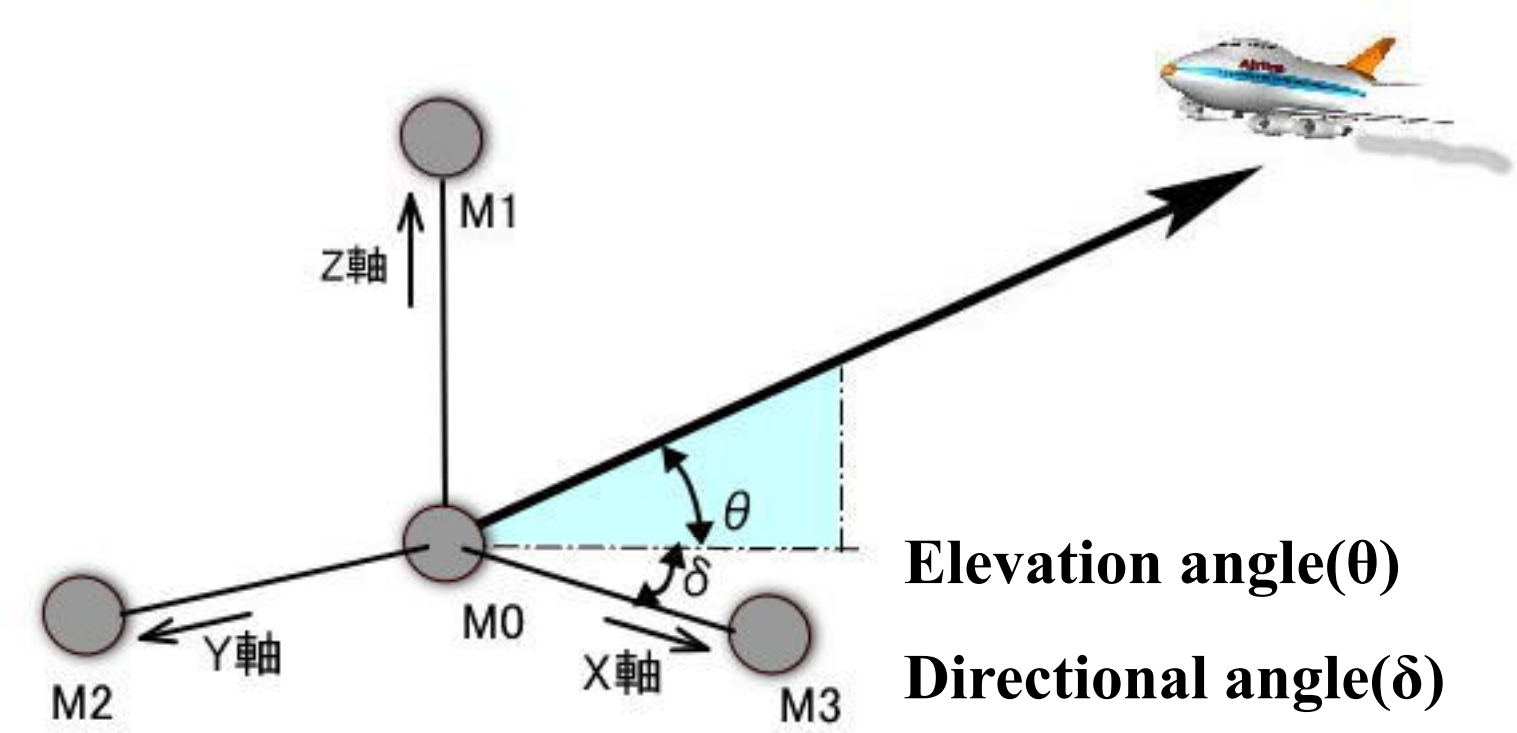
Aircraft sound discrimination



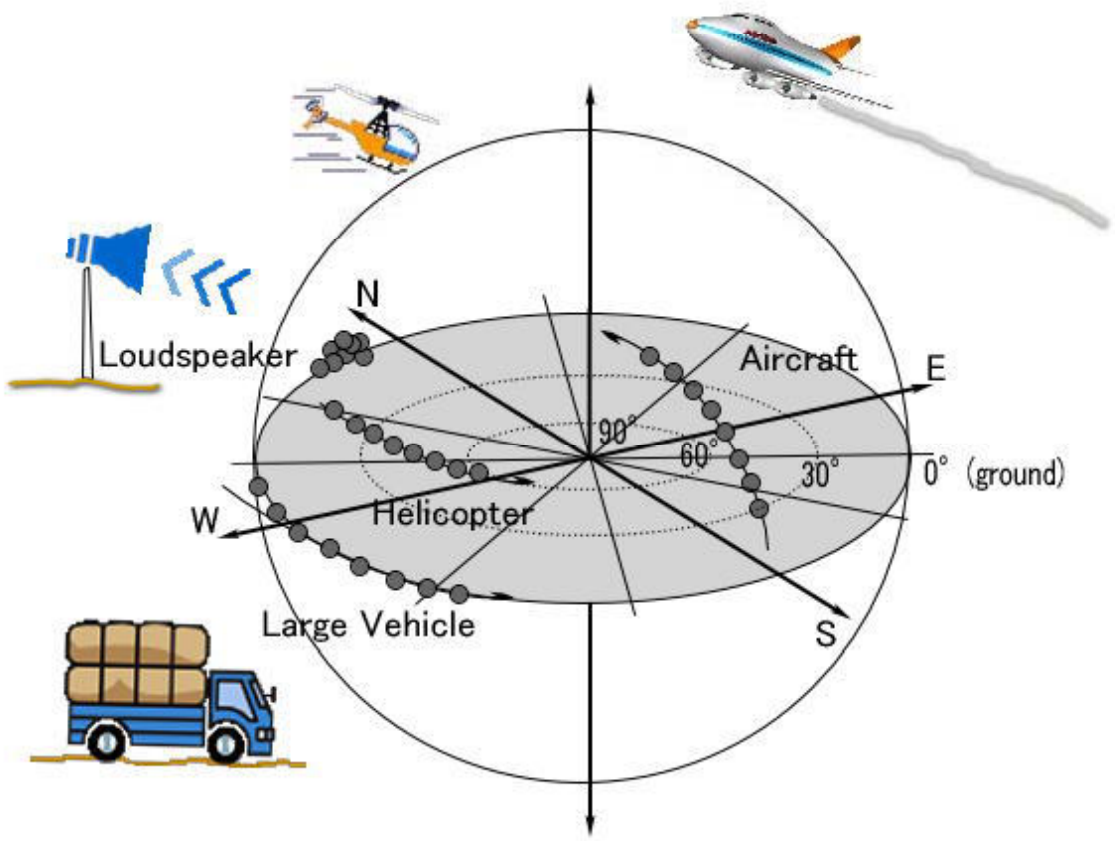
3D sound arrival direction

- Three axis microphone system

Records of the flight locus(elevation angle, direction angle)

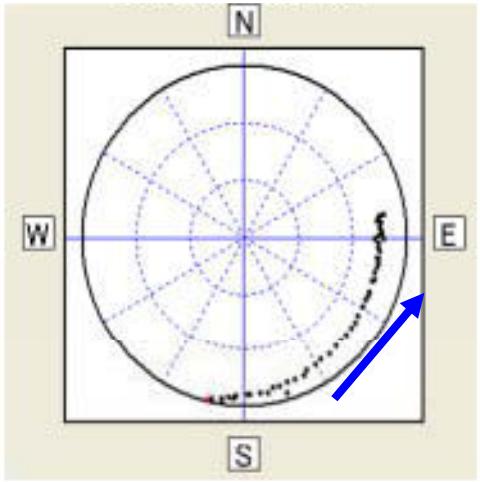


Pattern Analysis
using sound arrival directions



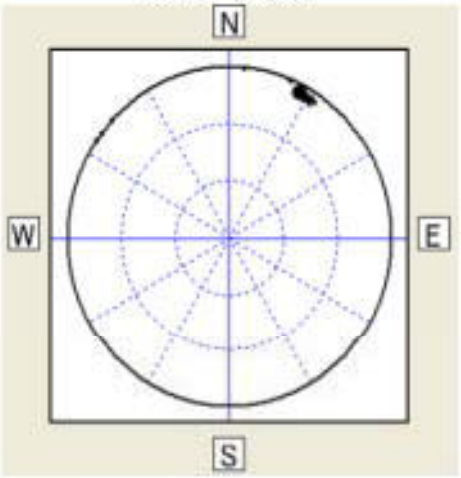
Typical sound arrival direction

South-east landing noise

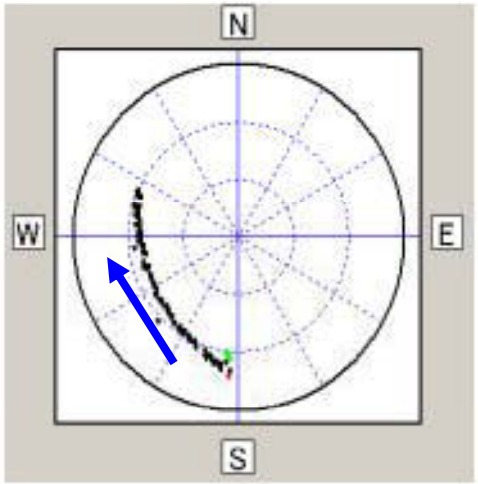


Above take off noise

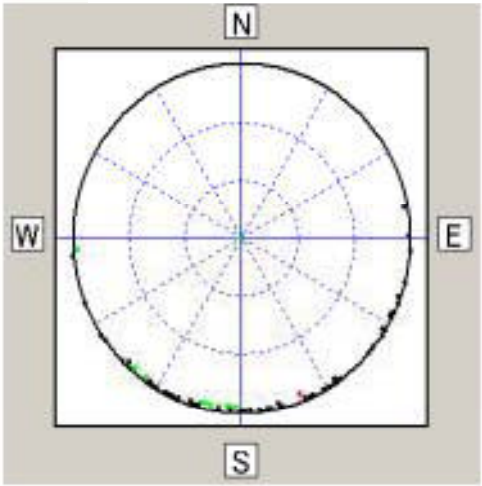
Reverse noise



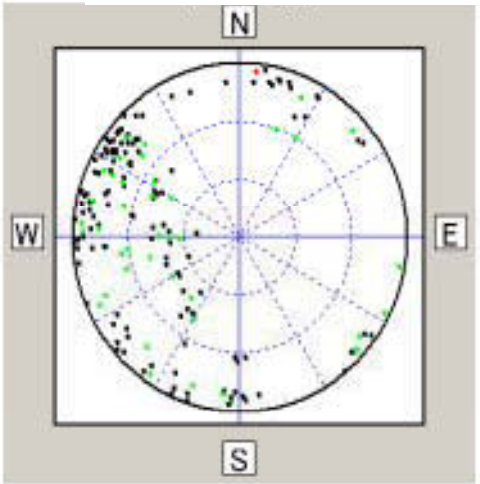
South-west takeoff noise



Car ground noise

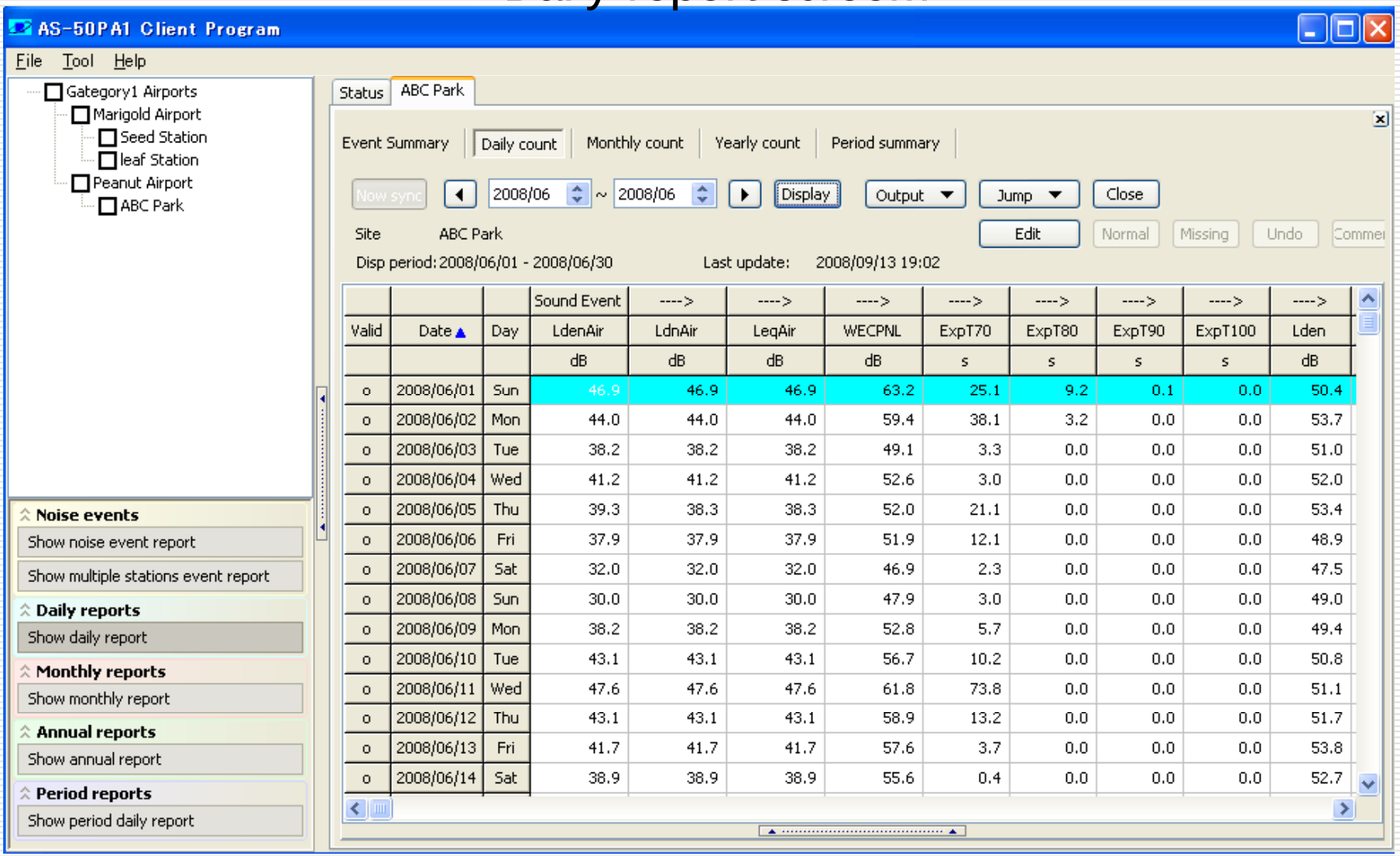


Wind noise



SA-50PA1 Software

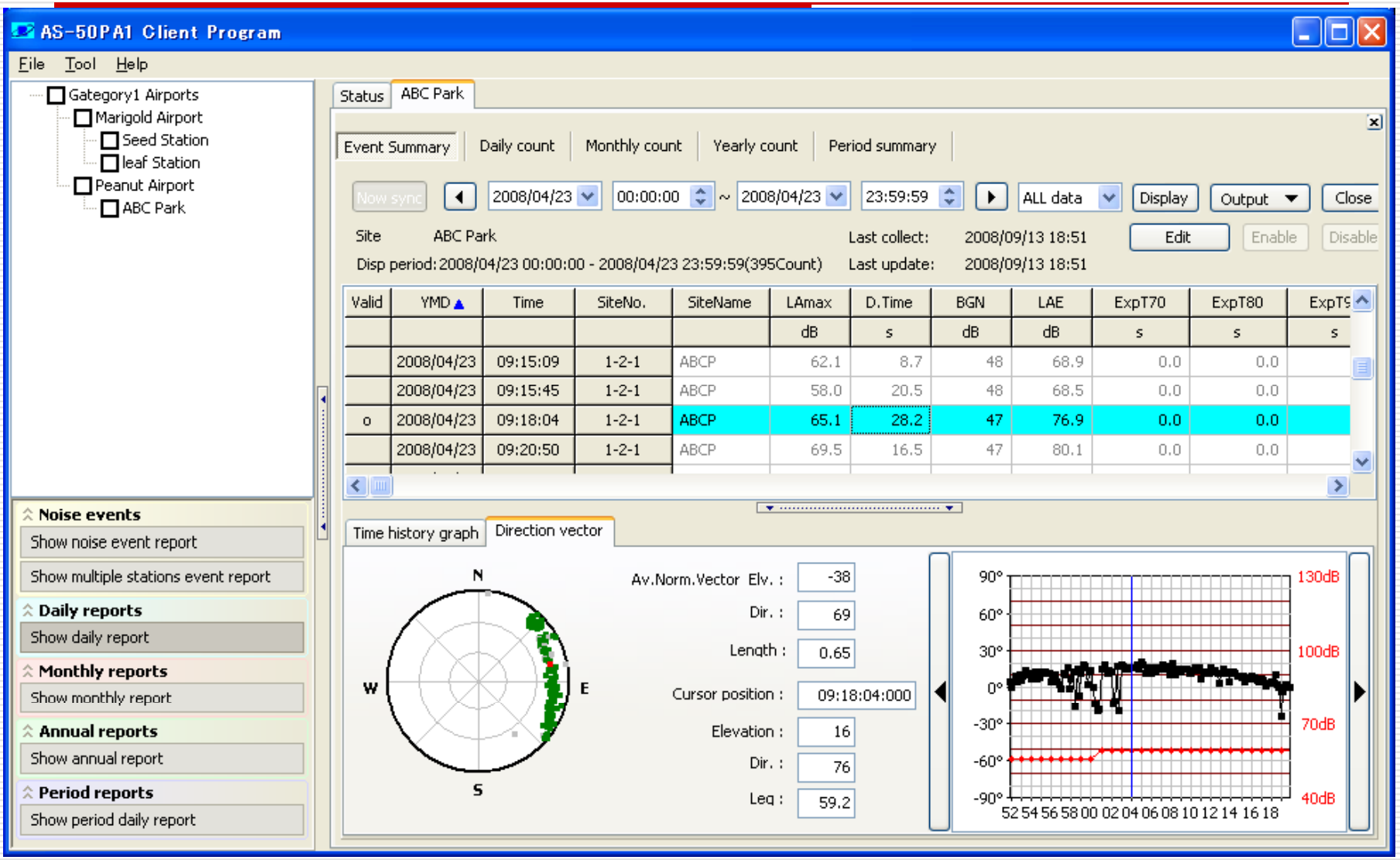
Daily report screem



			Sound Event	---->	---->	---->	---->	---->	---->	---->	---->
Valid	Date ▲	Day	LdenAir	LdnAir	LeqAir	WECPNL	ExpT70	ExpT80	ExpT90	ExpT100	Lden
			dB	dB	dB	dB	s	s	s	s	dB
o	2008/06/01	Sun	46.9	46.9	46.9	63.2	25.1	9.2	0.1	0.0	50.4
o	2008/06/02	Mon	44.0	44.0	44.0	59.4	38.1	3.2	0.0	0.0	53.7
o	2008/06/03	Tue	38.2	38.2	38.2	49.1	3.3	0.0	0.0	0.0	51.0
o	2008/06/04	Wed	41.2	41.2	41.2	52.6	3.0	0.0	0.0	0.0	52.0
o	2008/06/05	Thu	39.3	38.3	38.3	52.0	21.1	0.0	0.0	0.0	53.4
o	2008/06/06	Fri	37.9	37.9	37.9	51.9	12.1	0.0	0.0	0.0	48.9
o	2008/06/07	Sat	32.0	32.0	32.0	46.9	2.3	0.0	0.0	0.0	47.5
o	2008/06/08	Sun	30.0	30.0	30.0	47.9	3.0	0.0	0.0	0.0	49.0
o	2008/06/09	Mon	38.2	38.2	38.2	52.8	5.7	0.0	0.0	0.0	49.4
o	2008/06/10	Tue	43.1	43.1	43.1	56.7	10.2	0.0	0.0	0.0	50.8
o	2008/06/11	Wed	47.6	47.6	47.6	61.8	73.8	0.0	0.0	0.0	51.1
o	2008/06/12	Thu	43.1	43.1	43.1	58.9	13.2	0.0	0.0	0.0	51.7
o	2008/06/13	Fri	41.7	41.7	41.7	57.6	3.7	0.0	0.0	0.0	53.8
o	2008/06/14	Sat	38.9	38.9	38.9	55.6	0.4	0.0	0.0	0.0	52.7

SA-50PA1 Software

Event total screem



The End

Thank you
for your attention